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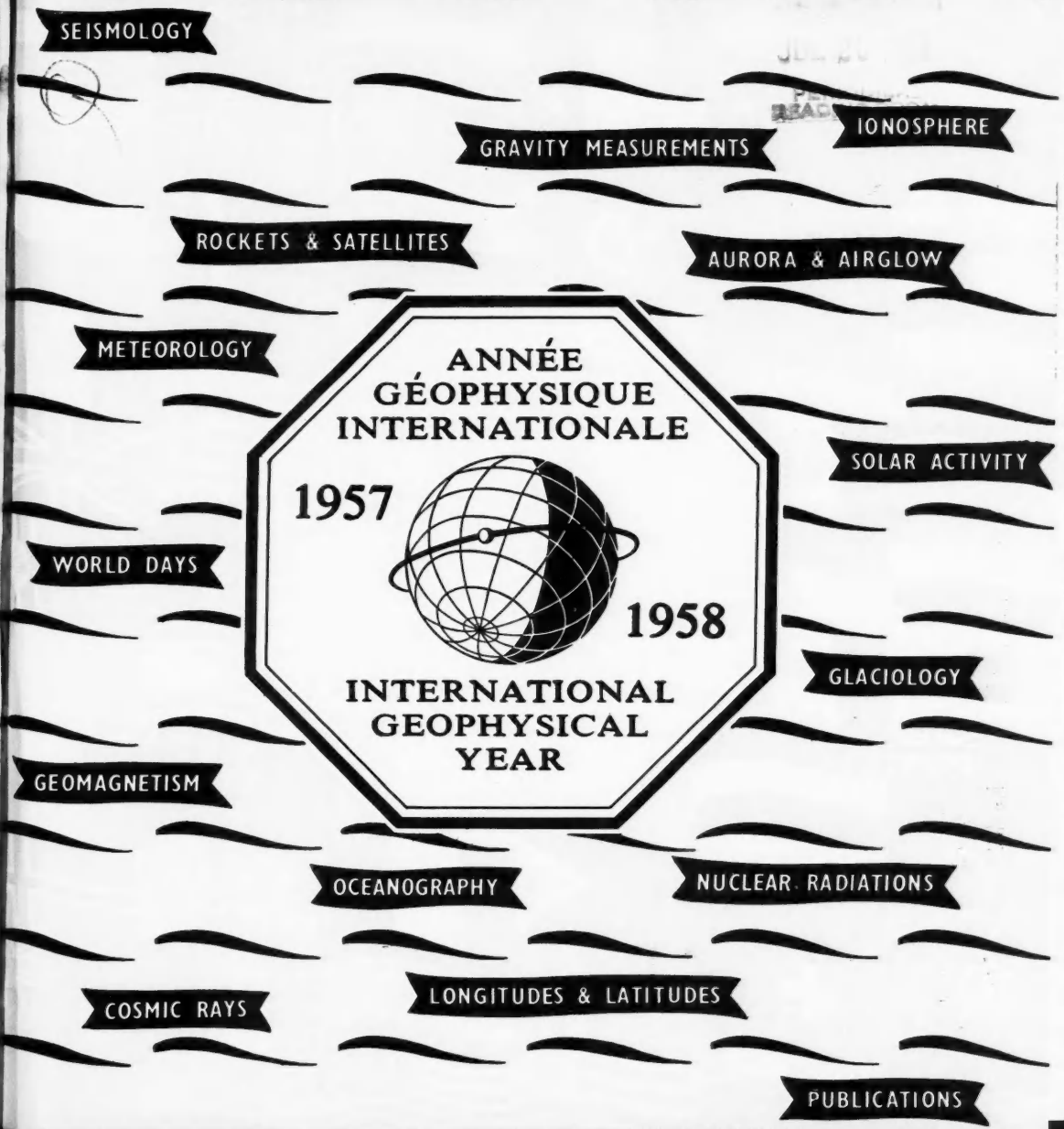
JULY 1957 2/6



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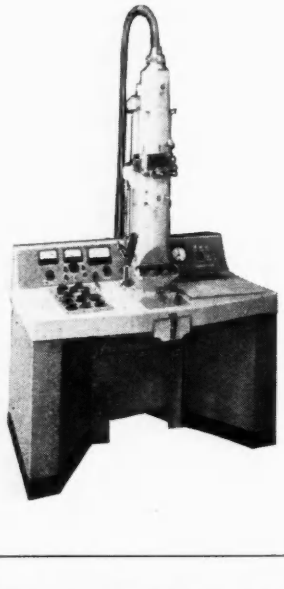

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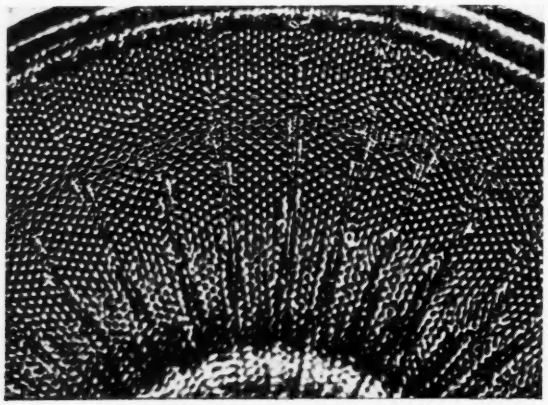

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COVER PICTURE: Our cover picture this month shows the symbol of the International Geophysical Year surrounded by the flags of most of the participating nations and by the names of the Sections of Research.

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Representative of the giant effort behind the scientific work of the IGY is the illustration above. It shows a U.S. Navy helicopter hovering above the icebreaker *Northwind*. The icebreaker is clearing a path to Moubray Bay, Cape Hallett, Antarctica, during Operation Deep Freeze II. (*U.S. Navy photograph.*)

THE INTERNATIONAL GEOPHYSICAL YEAR

The universe, now estimated to be 4500 million years old, contains millions of galaxies, each made up of millions of individual stars. One single one of this inconceivable multitude, is our own Sun. Since man has consciously recorded his knowledge, a mere 5000 years ago, he has come a long way, and yet he knows but little of his own planet which is not immediately below his feet, or a short distance above him. The surface of the Earth is now well mapped and charted, but the mantle and the core of the Earth is still only the subject of speculation, and the exploration of the regions of the upper atmosphere is just about to begin. To learn more about it, required a bold and courageous approach, on a scale of world-wide co-operation, backed by the resources of the governments of the nations; these were readily granted, to make the most modern type of observation possible. The fact that today science can command these resources for its work must be a great satisfaction to all scientists, and it has therefore been with some pride that DISCOVERY has chronicled the preparatory work for this great enterprise. To the best of our knowledge, it has been the only journal which has, since May 1956, regularly devoted space to the manifold activities of research workers all over the Earth, engaged in the common task of learning more about our own planet.

This month sees the beginning of this giant international scheme of scientific co-operation known as the International Geophysical Year. During the next eighteen months the various ways in which the Sun affects our planet, and these include the majority of geophysical phenomena, will be intensively studied by scientists of more than sixty countries. The measure of international agreement which has been secured in spite of the diplomatic controversies of the past few years can be regarded as the first important achievement of the IGY concept.

This basic concept of an international geophysical experiment is credited to an Austrian scientist, Weyprecht, who was disappointed with the scientific progress accruing from individual Arctic expeditions. He was among the first to appreciate the fact that great progress in geophysics can only be expected to come from simultaneous observations made at stations having a sufficient density over the whole region which requires examination. His ideas still require constant reiteration in a scientific age when many subjects being investigated are of the order of the laboratory bench and smaller, for the dimensions of geophysical phenomena are those of our planet and all our measuring devices are only small test bodies which we insert into their constantly changing formations. Weyprecht unfortunately did not live to see his ideas put into practice during the first International Polar Year in 1882–3, when a dozen or so stations were set up in the Arctic region. This joint experiment was

repeated fifty years later in the same region during the second International Polar Year in 1932–3. Great advances in scientific instrumentation and the hypotheses made to account for the resulting observations have been made during the past twenty-five years, so a third International Polar Year was suggested which was to embrace Antarctic geophysical studies as well as Arctic ones.

One of the major results of the second IPY was the confirmation of the correlation between large-scale solar activity and disturbances in the ionosphere. The correlation between solar activity, magnetic storms and auroral displays also received further confirmation. Usually a scientific experiment is best made, and sometimes can only be made, when the object of study is disturbed away from its stable position, and the Sun appears to be a suitable perturber for the further study of the above phenomena. The second IPY was held near sunspot minimum, but 1957–8 is close to sunspot maximum. Consequently it was not long before the study of the polar regions in 1957 evolved into a global study of phenomena which depend on the Sun—hence the IGY.

Scientific experiments tend to yield increased results for a given outlay of time and energy when they are well planned in advance. As the third IPY idea was first suggested in 1950 it can be assumed that the IGY will not fail due to ignorance of this basic tenet. The thirteen subjects to be studied were chosen either for their dependence on solar activity or the benefit that would be derived from their being the subject of an intensive global study, for example, meteorology and oceanography. Other subjects, such as latitude and longitude and glaciology, whilst yielding valuable observations for immediate consideration, will also provide material for comparison with similar observations made in future IGYs, so giving information about continental drift and glacier retreat. Seismological and gravity observations were added to the programme to take advantage of stations being set up in inaccessible places such as oceanic islands, Antarctica, and elsewhere.

Besides the scientific data which will result from these eighteen months of intensive studies, many permanent advantages for science in general are also being gained. A system whereby solar observatories report to a central forecasting agency, which in turn can notify each country if solar activity is likely to lead to a period of fruitful study, is surely an achievement which should not die with the IGY in December 1958. International science is organised by the Unions set up for each subject and they are linked by the International Council of Scientific Unions (ICSU). It is ICSU which has been responsible for the IGY plans, and all these bodies will benefit from having actually planned, developed and carried out a practical plan of observation. *Nullius in Verba* is the motto of the Royal Society of London, and the International Unions should heed the dictum as well and not hold back from organising further international schemes of observation in other subjects, so long as the plans are given sufficient time to mature. During the past seven years over sixty different national committees have approached their governments for large sums of money for their IGY programmes. In all about £100 million must have been secured for the IGY, and every time governments are successfully persuaded to support scientific research a useful precedent is created.

The Special Committee for the IGY (CSAGI) has now begun to produce the "Annals of the IGY", which will give the history of the scheme, the lists of participating stations, and a record of the solar activity of the eighteen months. Of even more permanent value will be some of the instruction manuals for the various subjects; maybe the ionosphere volume will be the standard textbook in that subject for the next decade.

Apart from the official records of observations, which in due course will no doubt be published, a number of more popular booklets and pamphlets about the IGY will make their appearance. The first to reach us is "Regard the Earth" by Dr R. Fraser, the ICSU Administrative Secretary (Science Club, 24 pp., 2*s*. 6*d*.). Full details of the IGY programme are given in a readily understandable form and a number of excellent illustrations are included. Dr Fraser is also the author of a book, "Once Around the Sun" (Hodder and Stoughton, 160 pp., 16*s*.). In the same clear and detailed style, he deals with the coming IGY activities. The book is divided into two parts, the boundaries of the known world, and its new horizons. It is full of good photographs. Methuen's "Guide to IGY" (2*s*. 6*d*.) has also been published and is a very useful summary of IGY ambitions. J. Wartnaby has also written a short pamphlet on the IGY for the Science Museum (H.M.S.O., 18 pp., 2*s*.). The Science Museum has mounted a small exhibition, open until the end of October. The publication deals with the Sun, the Atmosphere, and the Solid Earth, and contains a number of useful illustrations.

But it is not only by the printed word that the IGY is being made known. On June 28, H.R.H. Prince Philip attended the Royal Society Conversazione which was entirely devoted to exhibits dealing with the many scientific activities of the IGY; and two days later, on June 30, he acted as the compère to a BBC programme entirely devoted to the IGY. Associated-Rediffusion had as long ago as May 16 begun its series of eight science television programmes to schools, appropriately devoted to the International Geophysical Year; these have been well received, and are reviewed elsewhere in this issue. Perhaps amongst all the many formal and informal celebrations which have marked the beginning of the IGY, one should not forget the midwinter festivities which took place in the Antarctic on June 21, the traditional day for this merry-making.

Finally, tribute must be paid to the many members of the national IGY committees everywhere and to the many international organisations whose unflagging enthusiasm has made the programmes possible. DISCOVERY wishes good luck to all scientists engaged in the IGY, wherever they may be stationed; may their work be crowned with the success it deserves.

THE PROGRESS OF SCIENCE

SCIENCE FOR DEFENCE

The die has been cast. The decision has at last been taken to reshape Britain's defence forces in a manner that takes into account not only the reduced size of the national purse, but also the dramatic strides that have been made in science and in military technology since the end of the Second World War.

While we laud Mr Sandys, the Minister of Defence, who personally drafted the recently published "Defence Outline of Future Policy", for having had the courage to take decisions that a long and undistinguished succession of predecessors have lacked the strength or the foresight to take before him, we find it difficult to understand any justification except that of political expediency for his statement in the White Paper that "It is only now that the future picture is becoming sufficiently clear to enable comprehensive reshaping of policy to be undertaken with any degree of confidence." Perhaps it was difficult for him to say otherwise when one of his more recent predecessors was the Prime Minister who placed him in office.

The nature of the present threat against Britain, the appalling shadows of the thermonuclear warhead, and the long-range bombardment rocket have been obvious to any thinking man for some years.

Pentagon officials and the brass-hats of Whitehall have known of the threat for a much longer time. The Russian rockets, which present the greatest threat to Britain now, are developments of projects that fell alike into the hands of East and West when Germany capitulated. They are logical improvements of rockets of the A4, A9/A10 series, with one member of which, the V2 rocket, Britons can claim an all too intimate knowledge.

Equally the strong possibility that a hydrogen weapon would follow on the successful production of the ordinary atomic bomb was apparent to many of the Allied team which worked at Los Alamos on the Hiroshima and Nagasaki bombs. There was no excuse for anyone to ignore it from 1952 onwards. And yet scientists employed on Britain's own atomic project could get no authority at all to maintain even a watching brief of this work until the thermonuclear weapon project was fully initiated in December 1954.

The same almost unbelievable lack of foresight was shown in the matter of supersonic aircraft, to say nothing of the ground-to-air and the air-to-air rockets and ram-jets. The fact that in many of these fields Britain has been enabled to catch up rapidly some of the leeway must in great measure be laid to the credit of our scientists and engineers, who seem always to rise to the challenge of inadequate equipment, inadequate manpower, insufficient money, and practically no encouragement.

One of these days, no doubt, inquests will be held and we will discover, although much too late, why the responsible research establishments were dissuaded immediately after the war from following the obvious writings on the wall and pressing on to sonic and supersonic flight as America did. We may hear more of the rearguard battles fought by out-of-date air-marshals and admirals and General Blimps. Of more concern for the present and the future, however, is to assure ourselves that the right scale of effort is being devoted in defence research establishments to the stages ahead.

One outstanding example is that of the long-range bombardment rocket. We have been told by Mr Harold Macmillan that we may and must look to the United States for the intermediate-range ballistic rockets of the early 1960's. We have also been told that Britain has initiated a project of her own. What does it amount to? What little published information there is to go on suggests that little if any progress has yet been made, and that what is being done will only give us a nodding acquaintance with the problems that America will already have faced. It would appear to mean that by the early 1960's we will have progressed far enough to start thinking about building the sort of research vehicle that was required in the early development stage of the current American programme.

Surely Britain's rôle should be one step farther ahead. Instead of playing with conventional propellant motors that will be out of date by 1962, we should be putting an all-out effort into the development of more advanced fuels, including the boranes, so that we will have something to offer America for the next stage in exchange of the help that we hope to get.

THE CROFTERS OF DOUNREAY

At Dounreay the United Kingdom Atomic Energy Authority has established its second major research establishment, and what Harwell has done for pure atomic research, Dounreay hopes to do for the Industrial Group of the Authority. At present it consists of an experimental fast reactor (see DISCOVERY 1956, p. 470), a chemical group carrying out the fabrication of fuel elements, their separation and analysis, a special materials-testing reactor, a health physics and safety group, and a general research and development section. There can be little doubt that their work will contribute much to the future of industrial atomic power in this country and overseas, but one may hope that the name of Dounreay will not only become famous for industrial atomic energy but also in sociology. Dounreay is the ideal site for one of the most important sociological studies of the present time, but it seems that this fact has not yet been appreciated.

It is the unique situation of Dounreay which makes it of such great sociological importance. At the northernmost coast of the British Isles, the landscape surrounding the research establishment is something inherently foreign to anyone who has not travelled outside Europe and does not know the vast empty spaces of other continents. For miles around, the countryside is bare, partly flat, and partly mountainous. No tree grows, and no green

meadows enliven the earth on which the only living animals appear to be a few sheep. Naturally, the density of the population is extremely low, and their livelihood is by necessity of the poorest. The total number of inhabitants of Sutherland, the county adjoining Caithness in which Dounreay is situated, is but 13,000. It is perhaps therefore a pertinent question to inquire about the influence which the Atomic Research Station will have on the local population. It brings material wealth and a large influx of technicians and scientists to an area where the Vikings, who invaded this part of the country in the 9th century, are still a subject of conversation.

Quite rightly, the first concern of the Atomic Energy Authority is with the physical safety of its temporary and permanent employees, and much is done by the Authority directly and indirectly to ensure that life is pleasant and comfortable to those who must be far away from other large centres of population. But in the same scientific way in which the naturally occurring background radioactivity and radiation is carefully analysed before the fast reactor becomes critical, a similar background survey might well be carried out to determine the attitudes and reactions of the local population before work in the area becomes too advanced. Measurements are made of the natural gamma radiation and of the activity of the atmospheric dust. Samples of soil are collected and their radioactivity measured. Samples of the vegetation and of the roots are gathered and examined to determine how much activity is taken up by the plants from the natural radioactivity of the soil. Samples of sand, seaweed, shell-fish, sea-water, and edible fish find their way to the laboratory and to the radiation meters. The results are plotted on a large map, covered with concentric circles and with Dounreay as the centre.

It would be well worth while to plot a similar sociological map. There will be many factors to be studied, from the attitude of the people in the immediate neighbourhood to the economic influence of Dounreay to Scotland as a whole. These factors will change from year to year, or even from month to month, and when collated should reveal much about the influence of an atomic establishment on a population which is still unaquainted with its advantages and possible disadvantages. Such a study would not be of purely acedemic interest, however valuable by itself. It would prove of greatest benefit when British atomic power stations are erected in distant lands, amongst people vastly more ignorant about the atomic age than the crofters of Caithness. It can hardly be said that British industry has in the past shown great imagination in dealing with the populations of under-developed countries, and the recent political upheavals in the Middle East may perhaps be traced back, amongst other factors, to an unsuccessful public relations policy by the oil companies. One may therefore hope that the atomic industry of Great Britain, which is just about to be born, will learn from these mistakes, and in a truly scientific manner begin with a fact-finding survey on which to base its future policy. It is not yet too late to make Dounreay the sociological experiment it deserves to be.

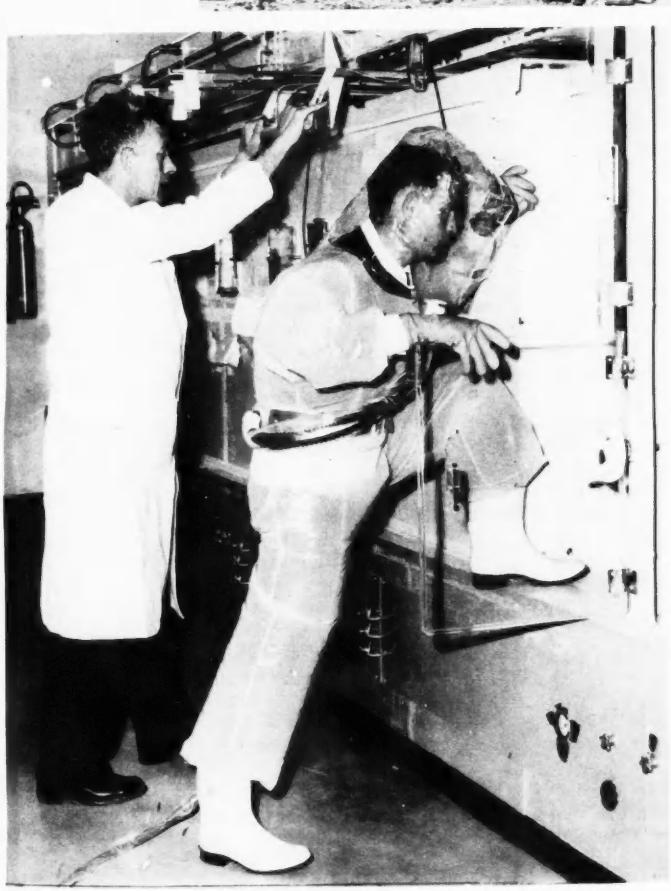
L. J. THÉNARD (1777–1857)

Of the eminent French chemists who contributed so much to the development of chemistry both in pure and applied aspects, Louis Jacques Thénard, who died a hundred years ago on June 21, was one of the most versatile. The anniversary affords an opportunity to pay a tribute overdue in England, and to re-assess Thénard's work from the standpoint of chemistry today. He was fellow-student and lifelong associate of Gay-Lussac, who has received better recognition. He was also a contemporary of Humphry Davy with whom he had links, since Davy, Gay-Lussac, and Thénard independently liberated the element boron by use of potassium and were all concerned with an intensive study of iodine after Thénard's one-time assistant Courtois had discovered this element. In an eighty-year span Thénard rose from the farmer's son and former laboratory boy of Vauquelin to become Chancellor of the University of Paris and peer of France.

On the one hand was Thénard's academic life as professor at the Ecole Polytechnique, with all the resulting influence he brought to bear on the advancement of both organic and inorganic chemistry. On the other were his discoveries in the field of applied chemistry: his "Thénard's blue" pigment for porcelain, and his preparation of hydrogen peroxide from barium peroxide, which was to remain the standard method of production for a century. From his schooling at Sens the sixteen-year-old Thénard went to Paris to take up pharmacy and to act as assistant to Vauquelin for three years. With the backing of Vauquelin and Fourcroy he took a teaching post at the Ecole Polytechnique, and there met Gay-Lussac to open a long partnership in the cause of chemistry. In 1804 he succeeded Vauquelin in the chemistry chair at the Collège de France, and five years later followed Fourcroy as professor at the Ecole Polytechnique. Such academic posts enabled Thénard to carry out considerable researches, so many of them in collaboration with Gay-Lussac that the two names crop up again and again in our chemistry texts as in so many published papers.

Even if Thénard were to be commemorated solely as teacher, his record would justify it. The comment of that eminent chemist Berzelius after attending some lectures given by Thénard at the Sorbonne is typical: "I have been a teacher of chemistry for twenty years, but not until now have I seen how it should be taught." Liebig also was enthralled by a teacher who could claim to have had 40,000 pupils attracted by his exposition and by his few but striking demonstrations in a lecture hall seating a thousand students. Thénard was equally successful in decisions he had to make as member of the court of the University of Paris or in matters affecting academic courses. Like other far-seeing men he believed so well in the appointment of young men of promise that Henri St Claire Deville was chosen for the chemistry chair at Besançon when only twenty-six years old—a decision which shocked the university councils at the time, yet which was fully justified by Deville's brilliant achievements soon afterwards.

But to turn to the discoveries and published work of



The technicians and scientists of Dounreay. What will they give to the crofters in years to come?

Thénard himself is to realise what a harvest was gathered in the cause of chemistry during the first half of the 19th century. That era was just dawning when the youthful Thénard produced his famous blue pigment for Sèvres porcelain, a discovery absorbing from one or two points of view. It was Chaptal, a French chemist who could combine the rôle of politician or statesman with his science, who as Minister of the Interior simply sent for Thénard, gave him 1500 francs to cover expenses, and told him to conjure forth a new blue pigment which would avoid high import-costs of other blues and would obviously have to withstand high temperatures. Within a month "Thénard's blue" was prepared, a blue mass of cobalt aluminate which, besides benefiting Sèvres porcelain manufacture, became known to every student of chemistry—or to those brought up in the classical analytical courses, in which charcoal tests using the blowpipe taught fundamentals in contrast to the current fashion for "spot" tests. Also at the opening of that fruitful half-century came Thénard's use of carbon dioxide for a more rapid preparation of white lead than obtained by using the older Dutch process.

We appreciate today the full impact on chemistry of Davy's preparation of the alkali and alkaline earth metals just 150 years ago. In 1806 Davy had been awarded a prize of 3000 francs, a prize founded by Napoleon, for his Royal Society paper on the chemical effects of an electric current. England and France were at war, yet their philosophers were not; hence there should have been no more surprise at Davy's award than when Davy and Faraday sailed between the French men-of-war on that memorable "grand tour" of Europe beginning with the French customs making out a passport for an Englishman to the utter amazement of an American tourist. Yet in 1807 Davy's master-stroke certainly caused consternation among French chemists as Napoleon called for some comparable discovery worthy of France. Placing two wires as electrodes on a piece of moist potash, Davy liberated tiny hissing beads of molten potassium metal and followed up the experiment by preparing sodium and other active metals. "Full of the odium of discovering sodium" as the clerihew goes, Davy's triumph reached the ears of Paris in 1808 and stirred things up. Napoleon in his chagrin, while asking whether such an English victory could be tolerated, caused to be constructed in the basement of the Ecole Polytechnique a huge voltaic battery, a fantastic affair of lead siphons, lead and zinc plates, barrels and troughs, all set to rival or outdo "that Englishman" in electrolytic work. And yet, although Gay-Lussac and Thénard in their "Recherches Physico-Chimiques" expressed thanks to the Emperor for *la grande batterie*, its use was but short-lived. Before the modern electrolytic preparations of sodium and potassium came into action, the focus of attention was on the reduction of soda or potash by iron or "iron carbide" at a high temperature. It was this reduction process for sodium originated in France by Gay-Lussac and Thénard which enabled cheap sodium to bring in turn the birth of the aluminium industry in the hands of St Claire Deville in 1854. Before this wider development which again entered the field of applied chemistry, the use of potassium by Thénard brought the discovery of boron, the element being liberated by reducing boric acid with potassium just as the sister element silicon was prepared by potassium reduction of silicon tetrafluoride. But Gay-Lussac and Thénard had to share their boron discovery with Davy's independent preparation—a link comparable with others.

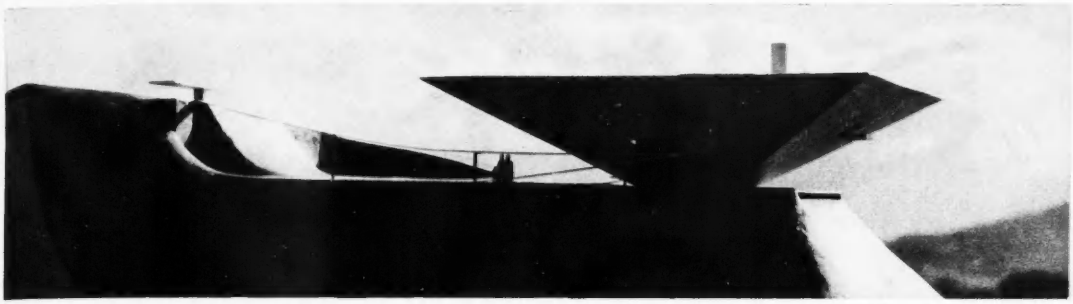
Further links with Davy's work in England were concerned with iodine, with the constitution of hydrochloric acid, with attempts to prepare that elusive element fluorine, and with the ultimate proof that sulphur is an element. Thénard and Gay-Lussac published a complete memoir on iodine after Courtois, trained at the Ecole Polytechnique, had discovered this element; yet Davy, to whom all was fish that came to his net, had his usual close interest in the novel element. Davy scored over Thénard and Gay-Lussac in banishing the remnant of Lavoisier's doctrine that acids must contain oxygen when he turned to hydrochloric acid. But with sulphur the converse was the case; for while Davy insisted that hydrogen was present, it was left to the two French chemists to establish fully its elementary nature. It is one of the wonders of chemical history that only in 1809 was the true nature of ancient brimstone substantiated. None of the three chemists succeeded in the difficult task of liberating fluorine from an eternity in bondage; yet it was not for want of struggling or suffering from toxic hydrogen fluoride which has taken its toll of a number of European chemists. Thénard's other published work includes studies on esters, on organic compounds later recognised as carbohydrates, on the oxidation of organic compounds, and on the preparation and properties of hydrogen peroxide filling eight papers.

How active was Thénard outside the laboratory is seen in his membership of the Société d'Arcueil, a society on a par with the Lunar Society of the Midlands, and in his duties as member of the Upper Chamber of Deputies when he sponsored the reprinting of Laplace's classics and enabled Pasteur to escape the servitude of routine teaching to carry out his inspired researches. Thénard is perpetuated in his native village renamed La Louptière-Thénard. But far more was his name handed down in that blue mass or impregnation obtained on charcoal as the young chemist-to-be sets to work with blowpipe and ubiquitous bunsen burner.

NEW SHAPES IN ARCHITECTURE

Recently three new buildings in the azalea-sparkling grounds of the Cement and Concrete Association were officially opened. The speeches by Sir Francis Meynell, the Director, and the Rt Hon. Hugh Molson, Minister of Works, give us a suitable opportunity to survey both the technical achievements and the artistic stagnation of Great Britain where cement and concrete engineering and architecture are concerned.

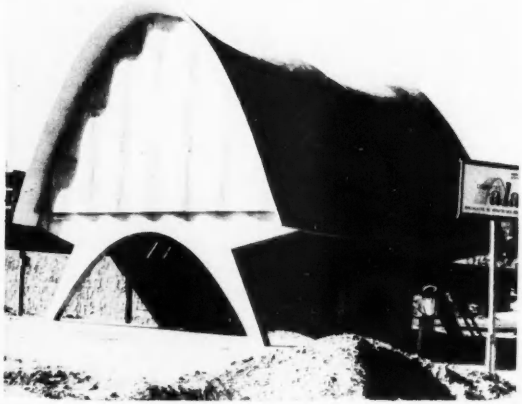
The achievements are solid, and the detailed scientific work of the Cement and Concrete Association has played a large part in ensuring that those who use these materials know precisely their qualities, how they will weather, what weights they will support, and so on. At

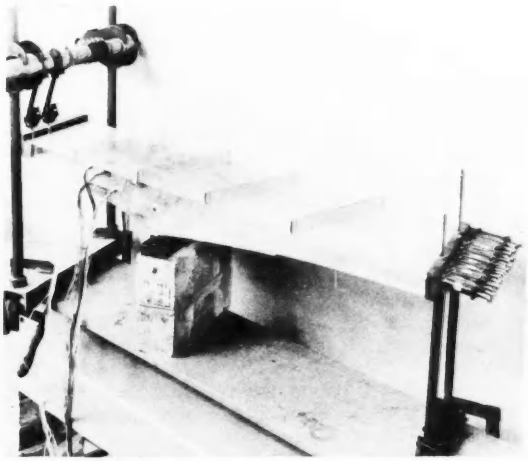


A model of the Caracas Museum of Modern Art, designed by the Brazilian architect Oscar Niemeyer. The building seems poised as if for flight. Similar photographs appear in a recent book, "Oscar Niemeyer: Work in Progress" by Stamo Papadaki, Reinhold Books, New York, Chapman & Hall, London.

courses, which are always full, the Association is training workmen at all levels of responsibility, and keeping engineers up to date with the knowledge gained from experience. The architectural stagnation is equally obvious to anyone who drives out along the Great West Road in the direction of the Training Centre at Wexham Springs. Pastiche façades are glued on to buildings structurally sound, but evidently the engineer has failed to receive any co-operation from the architect, who still thinks in terms of brick or stone rather than the newer materials at his disposal. No modern style will ever arise from this superimposition on to modern structures of forms belonging to another century. It is a tragedy that in this country today architects with imagination—and we have a number of them—are prevented from putting their plans into execution. Outmoded by-laws which still linger on the statute books, together with the way in which town planning legislation is administered in Britain, and committees determined that sham-Gothic and sham-Renaissance shall clutter the country of the Adam brothers, Vanbrugh, Wren, and the builders of York and Winchester and Canterbury, are the main hindrance. So France can have a church by Corbusier, Mexico can throw up a new University City in about four years, Brazilian architects can experiment until their buildings seem to fly like birds, but High Paddington and the Barbican Plan are squashed lest Wren should turn in his grave: as though the parasitic growth of suburban villas had not sent him sleepwalking long ago.

It is true that a building needs to keep out the wet, and either the heat or cold according to the climate. Latin-American architects, particularly, are working at a disadvantage in this respect, because they cannot yet be sure of first-class workmanship and sound materials. If some exchange could be arranged between these countries and ourselves, and if a body like the Cement and Concrete Association could use its reputation and foresight to encourage such an exchange, perhaps we would be persuaded to resurrect our lost sense of architectural style, and other countries might receive in return a standard of meticulous workmanship. The Association has already made a considerable contribution with its publications, as excellent in content as they are elegant in typography. They might well look now for ways and means to co-operate with other countries on a still more practical basis.





Left: Modern architecture comes to the aid of science in this cosmic-ray laboratory built in 1951 by F. Candelas in University City, Mexico. The concrete roof is only $\frac{3}{4}$ in. thick. *Right:* Test model of a part of the Clifton Bridge, a prestressed concrete bridge over the River Trent at Nottingham. (*Photograph by permission of the Cement and Concrete Association.*)

Aseptic transfer cabinets used for root and callus culture in the Department of Botany, Cardiff. The cabinets are fitted with Hanovia ultra-violet bactericidal units and are conditioned with a positive pressure of sterile air. (*Photograph by Hylton Warner.*)

"IS BIOLOGY TEACHING UP TO DATE?"

The biological sciences are still in process of becoming generally accepted within the curriculum of our grammar schools, and in many have yet to be provided with facilities comparable with those long since recognised as necessary for chemistry and physics. These comparatively recent developments in school biology not only arise from the growing recognition of its educational value in modern life, but from the increasing demand for trained biologists not only in medical and agricultural research but in industry and administration. These developments are making necessary a re-examination of existing syllabuses, a reassessment of the abilities required by the intending biology student, and a formulation of the minimum facilities which should be available to any biology teacher called upon to do advanced work.

These problems have recently been considered at a Conference for Teachers of Biology in Grammar Schools and Training Colleges held in the Departments of Botany and Zoology at the University College of Swansea. The first discussion of this Conference was on "Objectives in the Teaching of High School Biology" and was opened by Prof. C. D. Darlington, F.R.S., of the Botany Department of Oxford. Prof. Darlington emphasised that the approaches and descriptive methods developed by Linnaeus and by T. H. Huxley still dominated the objectives and methods of much present-day teaching. Such an approach ignored the major developments of biological science in the 20th century. There were a number of definite aims which every biology teacher should keep in mind. Each pupil possesses a range of abilities, and not one but a number of these are required by the biologist. The young biologist should be taught not only to make scientific discoveries, but to communicate them clearly. The natural ability of the pupil to handle living things should be developed. Handling of living organisms required a knowledge of apparatus and training in its use. The teacher could try to break down the rigid and artificial compartments into which knowledge was segregated. For example, what was learnt about lenses in physics was relevant to the pupil's understanding and intelligent use of the microscope. Though more attention would have to be paid to apparatus and instrumentation, training in the art of precise representation by drawing remained a fundamental way of developing critical observation in biology. The average elementary textbooks and outmoded traditions in teaching made it a difficult task to help the pupil see biology as a unity. We needed to rethink our teaching. We had to examine the alternatives in practical work to the dissection of Huxley's types, to reassess the functions of botanical gardens. Could not the formal collections of plants

arranged in their Linnaean families be usefully replaced by collections to show evolution in progress, variegated types, chimaeras, hybrids fertile and sterile, unstable species exhibiting high variability, varieties of cultivated plants alongside their wild ancestors? Could not the pupil himself frequently be the experimental subject? Children might have their blood groups recorded and compared with members of their own family; the distribution of blood groups within the school could be compared with that in other nearby and more remote schools, and the data used to bring out important aspects of physiology, genetics, and evolution. The development of ideas about organic evolution might be traced over the last hundred years; or Mendel's experiments, suitably modified, might be repeated and followed up by appropriate cytological studies.

Sessions of the Conference were devoted to "Advanced-Level Botany", introduced by Dr I. Isaac, Senior Lecturer in Botany and examiner in Botany for the Welsh Joint Education Committee and the University of London, and to "Field Studies in Zoology", introduced by Mr A. Macfadyen of the Zoology Department. There are three main aspects to the problem of the "Advanced Level" in a biological subject: the abilities of the pupils and their background in related sciences, the physical facilities available for teaching, and the objectives and difficulties of the teacher. The major difficulty facing both the school and university teacher was that of conveying a clear picture of the plant-kingdom as a whole, of developing an attitude of mind which enabled the student to select from his often quite detailed knowledge. Students frequently failed to understand biological data because of vague or incorrect knowledge of elementary physics and chemistry. They were unable to select, and were impelled to think along pathways determined by their textbooks or by lectures. Dr Isaac said that although pupils entering the university after passing advanced-level botany entered upon second-year work early, they did not compare unfavourably in their theoretical knowledge with students who had instead pursued a university intermediate course. In practical work, however, they were frequently less technically efficient and were lacking in powers of critical observation and interpretation as compared with students who had had to undergo a preparatory first-year university course.

In discussion a case was made against the present diversity of auxiliary subjects required by different universities for entrance. This made it extremely difficult for schools to cater for pupils who in any one year wished to enter different universities. Some standardisation of these requirements was called for. There was general agreement on the desirability of chemistry and physics for biologists at Advanced Level, and a number of teachers stressed the growing importance of an adequate training in mathematics. The training value of the "thesis", or piece of individual work required for Advanced Level by the Welsh Board was discussed. This raised one of the major problems which any reconstruction of existing syllabuses will meet. The restrictions of a wide and detailed syllabus, while ensuring a broad general knowledge, does not make it easy to capture the student's interest in a way that more advanced work reflecting the teacher's own special interest can do. On the other hand, any revision which gives scope to the latter activity can be criticised as encouraging very immature specialisation.

One of the four controlled environment rooms shared by the Departments of Botany and Zoology, Cardiff. (*Photograph by Hylton Warner.*)

Mr Macfadyen referred to the difficulty of fitting field studies into the framework of examination syllabuses. Such studies are, however, essential if the pupil is to understand the ways of animals and their inter-relationships, and the means by which biological information is obtained. Such activities are one of the most effective ways of breaking down the conventional barriers between sciences.

The interest shown by biology teachers in a Conference of this kind not only reflects the great importance of the problems discussed, but the value of developing closer links between the universities and the grammar schools. It took place against the background of the fine new biological laboratories recently opened at University College, Swansea.

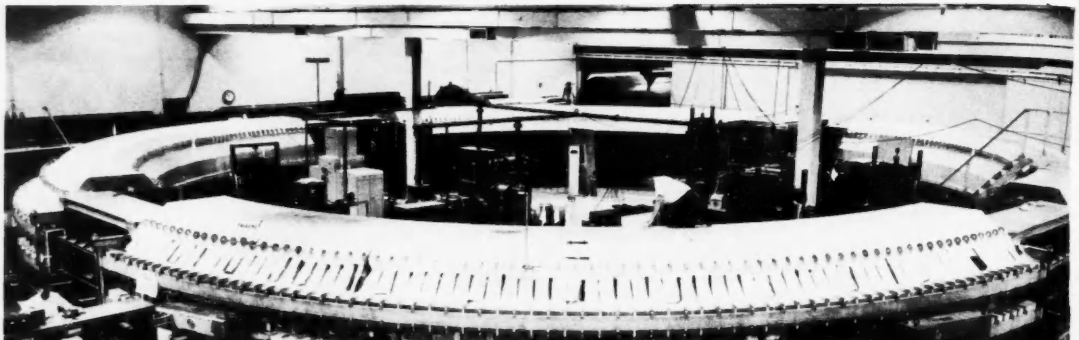


FIG. 1. The "Cosmotron" at the Brookhaven National Laboratory, Long Island, New York. The three units in front of the nearest magnet quadrant are vacuum pumps. The tank of the 4 MeV Van de Graaf injector is in the far background. (*The author wishes to thank the Brookhaven Laboratory for permission to use this photograph.*)

SOME ENGINEERING PROBLEMS OF THE CERN PROTON SYNCHROTRON

J. B. ADAMS

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The CERN Proton Synchrotron, now under construction on the CERN site at Meyrin, near Geneva, Switzerland, is a machine for accelerating protons, the nuclei of hydrogen, to energies higher than available from any existing accelerating machine. The ultimate energy of the accelerated protons emerging from this machine will be 25,000 million electron volts (25 GeV) where the unit, one electron volt, is the energy picked up by a charged particle accelerated by a potential of one volt. The existing proton synchrotrons nearest in output energy to the CERN machine are the Cosmotron at Brookhaven, Long Island, New York, of 3 GeV output energy, the Bevatron at the Radiation Laboratory, Berkeley, California, of 6 GeV output energy, and the Synchro-Phasotron at the Volga Laboratory, near Moscow, U.S.S.R., of 10 GeV output energy. The latter machine has just started operating at 10 GeV and is now the highest energy machine in the world. The two American machines have been in service for several years and have already made important contributions to high-energy nuclear physics, such as the creation of the anti-proton and the anti-neutron. Apart from these high-lights of discovery, proton synchrotrons in this energy range produce regulated outputs of mesons and hyperons, the nuclear particles of mass less than and greater than the proton respectively. In general, the reason for building these giant accelerators is to explore the atomic nucleus to discover the rôle of the many constituent parts of the nucleus and the nature of nuclear forces.

In a synchrotron the protons, after injection, circulate at a fixed radius in a magnetic field, gaining energy from electric fields spaced around their circular orbit. The magnetic guiding field increases from the initial injection field to the final field to maintain the radius of the proton orbit constant as the protons gain energy. The guiding field must also provide focusing forces, so that the whole beam of protons remains stable during the accelerating process. The proton velocities in these large synchrotrons approach the velocity of light and the time taken for a proton to complete one revolution round the machine is only a few microseconds. Consequently, the electric fields which accelerate the protons at each revolution are powered by a radio frequency source operating in the Mc/s range, whose frequency is varied during the accelerating cycle to keep in step with the increasing velocity of the protons.

It will be seen from this very brief description that proton synchrotrons have the physical form of a large annular magnet fed from a generator which increases the magnetic field from the starting field, when protons are injected into the machine, to a maximum field of 10–15 kilogauss, limited by the saturation of the iron yoke, in a time of about 1 sec. The magnet is divided into four or more sectors, and between them are field-free sections

in which are placed the R.F. accelerating cavities, error-correcting devices, and so forth. The protons cannot circulate in air, due to severe scattering losses by gas atoms, and therefore the space between the poles of the annular magnet is evacuated to a pressure of 10^{-6} mm. of Hg. Some of these constructional features can be seen in Figs. 1 and 2.

Such machines are clearly expensive, and since CERN was interested in constructing an even bigger machine than those illustrated, a simple scale-up of the existing designs would have led to a prohibitive cost. Fortunately, a new idea was discovered at the time the CERN machine was projected which made it possible to build a machine many times the energy of the existing machines for about the same capital cost. This new idea concerned the method of focusing the circulating protons. In the existing machines focusing is achieved by shaping the magnetic field to give relatively weak focusing, and consequently the circulating protons have large but stable amplitudes of oscillation, necessitating extensive magnetic fields and therefore a large cross-section of magnet yoke. The cost of the magnet, the exciting windings, and the generating plant is a large fraction of the total cost of the machine. The new idea, employing alternating gradient magnetic fields for focusing, gives a much stronger focusing action and greatly reduces the amplitude of oscillation of the protons, and hence the cross-section and cost of the magnet. However, these economic advantages are gained only by imposing very much tighter tolerances on the construction of the

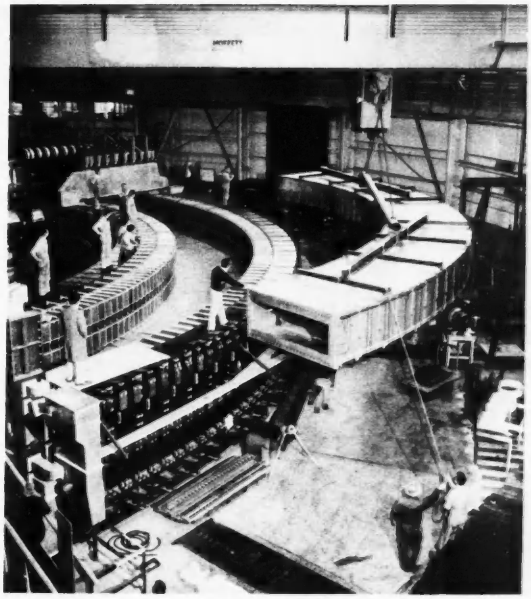

FIG. 2. The "Bevatron" at the Radiation Laboratory, Berkeley, California. The vacuum chamber in one of the magnet quadrants is being placed in position. The top yoke of the magnet is then installed. (*The author thanks the Radiation Laboratory, Berkeley, for permission to use this photograph.*)

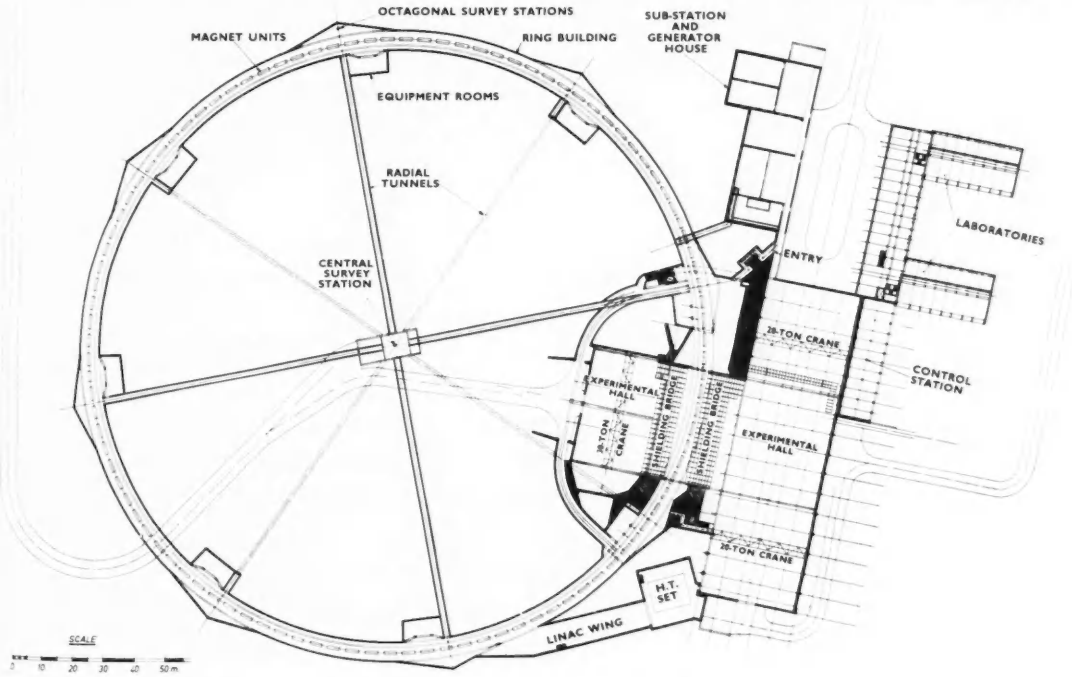

FIG. 3. Plan of the CERN Proton Synchrotron.

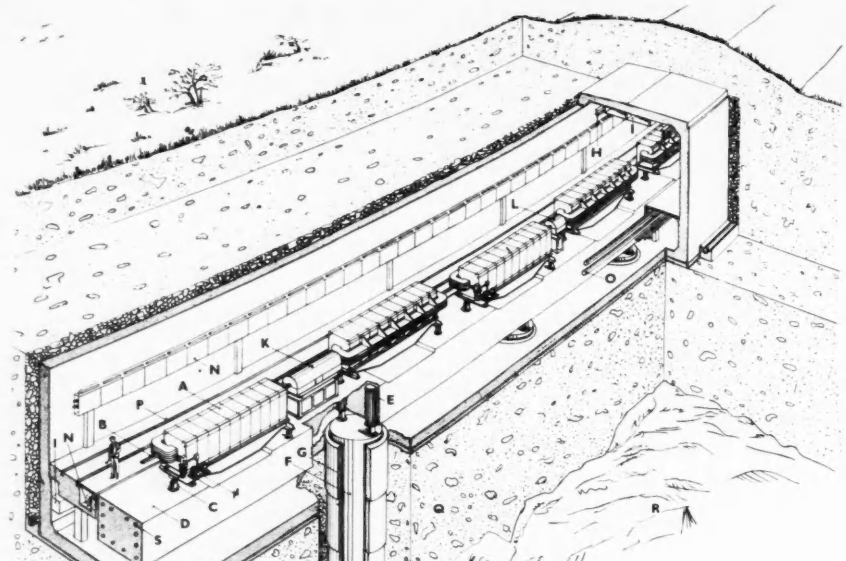

FIG. 4 (*left*). Section of the CERN Proton Synchrotron showing component parts and foundations.

A Magnet
B Vacuum chamber
C Screw jack
D Concrete ring
E Elastic supports
F Concrete column based on rock
G Bitumen
H Two-ton crane
I Ventilation
K RF cavity
L Lens
M Vacuum pump
N Electrical cables
O Magnet water-cooling
P Rails
Q Earth
R Rock
S Temperature-regulating water pipes.

FIG. 5 (*below*). Aerial photograph of building construction of the CERN Proton Synchrotron.

machine, and it is the object of this article to discuss some of the methods by which it is hoped to achieve these tolerances.

Figs. 3 and 4 show the layout and dimensions of the CERN Proton Synchrotron, and Fig. 5 an aerial photograph taken during the building construction.

STABILITY AND UNIFORMITY OF THE MAGNET

In the present weak focusing machine the physical alignment of the magnet is not especially critical. The permissible misalignments of the magnet sectors of the alternating gradient machine are about one-hundredth those of the weak focusing machines. From the protons' point of view it is the irregularities in the guiding field that matter, and these come from two types of error: either the magnet sectors themselves are misaligned, or there are variations in the guiding field of perfectly aligned magnet sectors. Thus the problem is divided into a mechanical one of aligning a magnet 200 m. in diameter, and keeping it aligned, and magnetic one of ensuring uniformity in the magnetic characteristics of the different sections of the magnet.

Before discussing these problems any further, it is useful to introduce at this stage the idea of a "closed orbit" and to relate all the tolerances to their effect on this closed orbit. The CERN alternating gradient machine has a magnet 200 m. in diameter, and the cross-section of the useful region of the field in the gap of this magnet is about 8 cm. high by 15 cm. wide. Throughout the accelerating process, during which the protons travel a distance approximately equal to the separation of the earth and the moon, the protons must stay inside this region or they will be lost by collision with the walls of the vacuum chamber. If the magnet was perfect and the frequency of the R.F. accelerating system was perfectly matched to the magnetic field at all times during the accelerating cycle, the closed orbit would be a perfect circle and lie in the centre of the magnet gap. Any proton injected with the appropriate energy, at the correct angle, and at the right time, would go round this closed orbit during the whole accelerating period, gradually gaining energy. However, since a beam of protons of finite cross-section is injected, none will exactly follow the closed orbit; they will all perform stable oscillations about it. Imperfections in the guiding magnetic field or misalignments of the magnet sectors cause the closed orbit to develop wriggles both in the radial and vertical plane. Imperfections in the tracking of the frequency of the accelerating voltage and the magnetic field cause the mean radius of the closed orbit to increase or decrease. It is clear that protons will only be accelerated to the maximum energy in the machine if, throughout the whole accelerating cycle, the closed orbit stays within the vacuum chamber. Even if this essential condition is observed, not all the protons will be accelerated, since those with large amplitudes of oscillation about the closed orbit will be lost to the walls of the vacuum chamber if any part of the closed orbit approaches the walls. Therefore, it is necessary to limit the deviation of the closed orbit from the centre of the vacuum chamber, and for design reasons the limits aimed at are $\pm$ 1 cm. for the peak of the wriggles and $\pm$ 1 cm. for the mean radius variation.

Returning now to the mechanical problems of magnets, these can be divided into those problems concerned with the stability of the structure that supports the magnet, and problems of aligning the magnet sectors to form the complete ring. If the magnet sectors are not correctly aligned, or the foundation of the magnet is not stable and misalignments occur after the original setting up, the closed orbit will be distorted from the perfect circle and

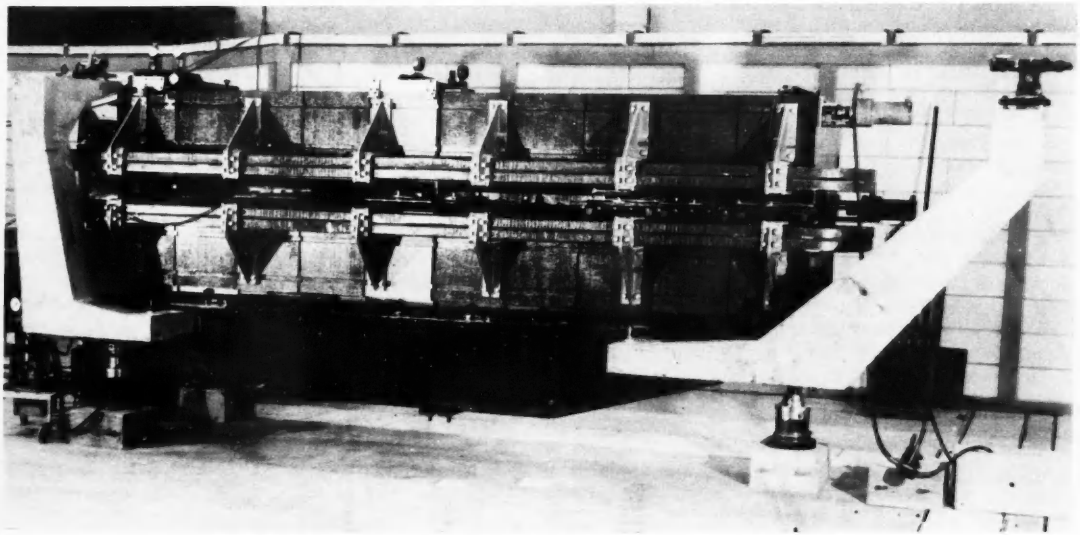

FIG. 6. A magnet unit. One hundred of these units form the complete magnet.

will have the form of a slightly buckled bicycle wheel. The errors can either be expressed as random misalignment errors, or broken down into their component space harmonics. In the CERN machine the magnet is divided into one hundred magnet units, each one about 4·2 m. long and weighing about 30 tons. Each unit comprises ten magnet blocks mounted on a heavy steel girder, and the unit rests on three jacks (Fig. 6) which stand on a circular beam of concrete supported by pillars cast into the sandstone rock under the site (Fig. 4). If the ends of these units are randomly misaligned between the limits ± 0·7 mm., the peak closed orbit deviation will reach 1 cm. However, this is but one of the causes of a distorted closed orbit, and the measuring tolerances for aligning the units have been fixed at ± 0·1 mm. Since the radius of the machine is 100 m., such a tolerance means measuring the position of the magnet units to 1 part in 10^6. From the point of view of the stability of the foundations of the magnet, it is better to look at the spatial harmonics of the possible distortions, since the concrete ring beam is most likely to distort in this fashion, and also since such considerations at once show the sensitivity of the machine to certain harmonics of the distortion. The first interesting harmonic of distortion is the second, which converts the circle into an ellipse. A second space harmonic amplitude of 3·8 cm. would give a closed orbit displacement of 1 cm., so this is not very serious. The sixth space harmonic is more critical; an amplitude of 0·36 mm. results in a closed orbit deviation of 1 cm. It can be seen from these figures that the foundations of the CERN machine have to be very stable indeed.

For a machine 200 m. in diameter it is impracticable to design a foundation that is completely independent of ground movements. During the past two years precise surveys have been carried out to discover what ground movements are to be expected on the CERN site. These surveys have shown that the moraine surface layers are not sufficiently stable, and it has been decided to place the foundations in the underlying sandstone rock. Unfortunately this rock is not homogeneous and in places it is over 6 m. below the surface. The pillars have therefore been joined at their top ends by a circular beam of concrete 200 m. in diameter and 2 × 2 m. in cross-section. It has been arranged that the moraine soil movements are not transmitted to the pillars. If this ring beam is solidly joined to the pillars, the resulting structure is temperature-sensitive due to the preponderance of tangential stiffness over radial stiffness. However, by inserting elastic supports between the ring beam and the pillars, these stiffnesses can be made nearly equal, and in the horizontal plane the ring beam is more or less floating. A floating ring beam 200 m. in diameter and only 2 m. square in section is flexible, and it is necessary to incorporate a damping system to prevent a build-up of oscillations energised from the rather frequent though small seismic disturbances observed in the neighbourhood of Geneva. The annular building which contains the ring beam and the magnet is built underground to prevent the radiation level on the site from exceeding the allowable tolerances. The air around the ring beam is temperature-controlled to ± 1°C and water is circulated around the whole ring beam to prevent any part from assuming a different temperature from the mean. It is calculated that these precautions should result in a sufficiently stable foundation for the magnet.

Aligning the magnet units on the ring beam to an accuracy of 1 part in 10^6 is feasible using the best modern theodolites and suitably aged invar wires. The ring building has eight radial tunnels, a central survey monument, and eight survey monuments inside the building (Fig. 3). Using a triangulation system it is possible to set up the octagonal markers to an accuracy exceeding 1 part in 10^6. A hexagonal system was deliberately avoided due to the sensitivity of the machine to sixth-space harmonic distortion which would seriously amplify any errors in the triangulation survey. From the eight survey markers in the ring building, the magnet units will be aligned using angle and length measurements. Optical measurements using theodolites inside tunnels are liable to refraction errors due to transverse thermal gradients. For example, an average transverse thermal gradient of 0·01°C per m. along a sight-line 100 m. long gives a sideways error of 0·1 mm. at the far end. It is quite impracticable to design an air temperature regulating system to eliminate such small gradients, and a solution has to be found in which the air is vigorously stirred along the sight-line to prevent consistent transverse thermal gradients.

CHARACTERISTICS OF THE MAGNET

Just as random misalignments of the magnet units distort the closed orbit, so do variations in the magnetic guiding fields of the separate units. The magnetic problems are therefore concerned with making the 1000 magnet blocks as similar as possible. The blocks are laminated to avoid eddy current effects and mechanical uniformity is obtained by punching the laminations in a precision die. It has been found that the optimum thickness of lamination for this sort of operation is 1·5 mm. After deburring, the laminations are glued together in a very accurate jig using paper insulation and a thermo-setting glue. The resulting mechanical tolerance for the assembled blocks is about 0·05 mm. An important problem is the uniformity of the steel used for the magnet laminations. There are two types of steel suitable for large synchrotron magnets, namely low silicon steels (about 1% silicon) and annealed low carbon steels. At injection the magnetic field required to bend protons of 50 MeV energy in a circle of 100 m. mean radius is 150 gauss. Both low silicon steels and annealed low carbon steels can be made with a coercive force as low as 1 oersted, which with the CERN magnet geometry gives a remanent field in the magnet gap of about 20 gauss. This is well below the injection field of 150 gauss and there is no need to reduce it further. Variations in the coercive force in the steel will cause variations in the remanent field of the different blocks, which in turn distort the closed orbit. Similarly, variations in the permeability of the steel also cause block to

block differences. For example, if the blocks are made sequentially from a steel which has random coercive force variations of ± 0·1 oersted averaged over a block, then the random block to block field variation will be 2 gauss, and at the injection field of 150 gauss the peak closed orbit amplitude will be 4 cm. Now ± 0·1 oersted is a very tight tolerance on industrial magnetic steel, and 4 cm. is too large a closed orbit amplitude. However, if it can be arranged that each block is made from laminations taken from the whole steel delivery instead of some part of it, then the magnetic variations will occur inside a block, where it does not matter, and not between blocks. This means arranging that the laminations are mixed in some way, and mixing 4000 tons of steel laminations is no trivial matter. The steel production and the block production for the CERN magnet are planned therefore in the following way.

Low carbon steel similar to that used for the manufacture of car bodies has been chosen as the primary material. Special care is taken at the steel plant to control the chemical composition of the steel and to select the best ingots. The ingots go through the normal hot-rolling sequence used for car body steel, and this is followed by very carefully controlled cold reduction. At this stage the strip is cut into sheets about 1 m. square, which are then stacked in piles and transferred into a special annealing furnace. The combination of cold reduction and subsequent annealing, by encouraging crystal growth, reduces the coercive force from the normal value of over 2 oersteds to slightly below 1 oersted. After oiling, the sheets are packaged and sent to the block-maker together with samples taken from each package, from which the relevant magnetic properties of the steel in the packages are measured. A large steel store is provided at the block-making factory, and piles of packages are built up on the floor of the store in such a way that the variation in coercive force between the packages in a pile is very much less than ± 0·1 oersted, whereas between the piles the variations can be larger. There are the same number of piles as laminations in a block, and each block is assembled by taking the top lamination from each pile after the whole store is completely filled, passing these in order through the punching die, and assembling them with paper insulation and glue in the jig. Finally the glue is cured in a furnace and the block becomes a rigid unit. Since each block contains a lamination from each pile, and there are about 250 laminations in a block, the variations in coercive force between the blocks should be $1/\sqrt{250}$ times the spread of coercive force in a pile. It is expected that the resulting coercive force variation between blocks will be about ± 0·01 oersted, which will give a closed orbit deviation of 0·4 cm. at the injection field.

FREQUENCY STABILITY REQUIREMENTS

As mentioned above, the closed orbit only stays in the centre of the vacuum chamber during the acceleration cycle if the frequency of the accelerating voltage is accurately related to the magnetic field at all times. Errors in this relationship cause the closed orbit to expand or to contract in radius. Protons are injected into the machine with an energy of 50 MeV, and after about 1 second they reach the final ejection energy of 25 GeV. Since the rest energy of the proton is about 0·9 GeV, a velocity near that of light is reached soon after injection. Therefore the generation of the instantaneous frequency is not simple, and in the CERN machine a fast analogue computer calculates and produces the required frequency during the acceleration using field measurement as primary data. No analogue computer is perfectly accurate, and the one built at CERN has tracking errors of a little less than 1 part in 10^3.

One of the disadvantages of the alternating gradient machine is that during the acceleration cycle the radial displacement of the closed orbit for a given frequency error does not remain constant. In fact at one critical energy, called "transition energy", which in the CERN machine occurs at about 5 GeV, the smallest frequency error causes an infinite displacement. Therefore no practical computer can operate satisfactorily near the transition energy, and other means of generating the correct frequency law must be employed. For a closed orbit displacement of 1 cm., the frequency errors that give such a displacement can be tabulated at different energies during the acceleration cycle.

Kinetic energy of protons	$\Delta f/f$ *(frequency error for 1 cm. closed orbit displacement)*
50 MeV	$3{\cdot}5\ 10^{-3}$
1 GeV	$8{\cdot}3\ 10^{-4}$
2 GeV	$2{\cdot}7\ 10^{-4}$
3 GeV	$1{\cdot}2\ 10^{-4}$
4 GeV	$4{\cdot}5\ 10^{-5}$
5 GeV	0
7 GeV	$5\ 10^{-5}$
10 GeV	$7\ 10^{-5}$
25 GeV	$7{\cdot}5\ 10^{-5}$

It can be seen that the CERN computer will operate satisfactorily until the protons have gained 1 or 2 GeV kinetic energy, but at higher energies other means must be used to control the frequency of the accelerating voltage.

The method proposed is to use the beam of particles itself to control the frequency. If the closed orbit shifts radially due to an error in frequency, the whole beam shifts with it and radial pick-up electrodes can immediately detect this shift. For instance, two suitably shaped plates placed either side of the beam will detect radial beam shifts by electrostatic pick-up, and their output signal, which can be made proportional to displacement, can be fed into the computer as an error signal to correct the accelerating voltage frequency. This is the principle of what is called "beam control", which is essential for alternating gradient machines, but of course in practice the whole system is very complex, involving many servo-loops using not only the beam shift as an error signal, but also the relative phase of the beam bunches and the applied RF voltage.

CONCLUSION

Perhaps these three examples are sufficient to give an impression of the sort of difficulties facing the engineers and physicists designing and building very large accelerating machines. Nearly all branches of applied physics are involved in the design, and due to the size of the project most of the parts have to be built by industry. This means that solutions must be found that can be employed by industry using existing or not too revolutionary techniques, and even then industry has to be persuaded to accept and carry out the methods evolved on a rather large scale. The division of CERN involved in this work numbers about 150 staff of all grades, including mechanics, draughtsmen, technicians, engineers, and physicists. Contracts for the component parts of the machine are placed all over Europe and are distributed on a competitive basis; the lowest priced tender that is technically acceptable determines the placing of the order. The staff themselves have been recruited from the twelve member States of CERN through national centres and by advertisement. There is only one other alternating gradient machine of a comparable energy to the CERN machine at a similar stage of construction in the world, and that is being built at the Brookhaven National Laboratory on Long Island, New York, by the same group that has successfully built the 3 GeV Cosmotron.

PAPERS DESCRIBING IN MORE DETAIL THE PROBLEMS MENTIONED ABOVE

1. Ramm, C. A. et al., "Considérations sur l'électro-aimant d'un synchrotron à gradient alterné", *Proceedings CERN Symposium 1956*, vol. 1, p. 307.
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NEW REMOTE-CONTROLLED MICROSCOPE FOR ATOMIC METALLURGICAL RESEARCH

Inspection of materials which have been exposed to nuclear radiation so intense that the test-pieces have to be shielded present the metallurgist with serious problems. The solution seems to have been found in America, where scientists study the changes that occur in the microstructure of metals exposed to nuclear bombardment. A new microscope has been described, dealing with materials having radiation so intense that the optical system of the microscope eventually goes "blind". A metallurgist focuses the equipment remotely during his research activities in microstructure changes.

At the Plutonium Plant at Hanford, Connecticut, U.S.A., General Electric scientists use the instrument to study changes that occur in the microstructure of metals exposed to chain-reaction bombardment. The information they gain is valuable for developing alloys and fabrication methods that will make atomic structures withstand increased radiation exposure. The various pieces examined in this work have been deformed by radiation and, in the process, have become ray-emitters. As a result, the Hanford microscope is eventually damaged by these rays.

All work is done remotely inside the 38-ton steel cell which houses the radioactive sample. First, the sample is placed in the cell by means of mechanical "hands" powered by electric motors.

Such a "hand" removes the sample from a lead container and positions it against grinding and polishing wheels. Then, electrical etching equipment removes the top layer of metal which has been made into a "non-typical microstructure" by the heat of the grinding. Mechanical "fingers" place the radioactive sample on the microscope stage, and the metallurgist manipulates sensitive controls to bring into focus one of three compound objective lenses.

Light beamed through a wall port is focused to a bright pinpoint, illuminating the polished sample of metal inside the cell. Reflected light from a circular dot of metal, sometimes as small as five-thousandths of an inch in diameter, is collected by a compound lens and projected through another wall-opening to an external eye-piece. There it is transformed into a vastly enlarged image of the circular area.

The instrument can optically separate two elements of grain structure one-thousandth of an inch apart. In effect, it places the observer's eye within 1/250 inch of the "hot" surface and still allows the eye to focus.

THE RAT'S WORLD

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Wild rats have a reputation for almost superhuman skill and cleverness. They are often supposed to be able to distinguish poisoned from harmless food; they are said to detect the dangers of traps (though sometimes only if these "smell of man"); and the effort to put a stop to their depredations on our food stores has been seriously described as "a veritable battle of wits". R. A. Davis has effectively disposed of the principal myths connected with the destruction of rats as pests (DISCOVERY, 1956, p. 115). They are all examples of what the psychologists call *projection*: we try to use our intelligence in the attempt to get what we want and to avoid what we dislike; and we sometimes attribute a corresponding thoughtfulness and ingenuity to other species. We shall see below how misleading it is to treat the feeding behaviour of rats as if it were based on reasoning.

Projection accounts also for many stories about social co-operation in rats. In one much-read work there is a solemn account of adults guiding young ones away from poison bait. If this is based at all on observation, the older rats were, in fact, probably pushing the young out of their way. This may be regarded as paralleling one aspect of human behaviour, but it has no moral significance.

Have rats really any complex social behaviour at all? The answer to this question is beginning to come partly from observing wild rats in the field or in large enclosures, partly from laboratory experiments. As a result we are now beginning to get some detailed knowledge of the life of an "average" small mammal.

THE INVADING SPECIES

The rats whose feeding behaviour and social life is being studied are of the common "brown" type, *Rattus norvegicus* Berkenhout, now generally distributed in our farms, sewers, and warehouses. The albino variety of this species is the familiar white rat used in laboratories. *R. norvegicus* is a burrowing animal. Before its arrival in Europe our only rat was *R. rattus* Linnaeus, the so-called black or old English rat, a climbing species of smaller size than *norvegicus* and also of world-wide distribution.

The remarkable success of these two species in association with man is a reflexion of their versatility, especially in their choice of food. Think of anything eaten by men, anywhere, and rats can eat it too. They have, indeed, a wider range than man, since they can subsist almost entirely on raw cereal grains or, as in glue factories, on the offal from animal carcasses.

FEEDING BEHAVIOUR

This versatility depends on behaviour patterns and types of learning ability which have become clear during the past two decades. The first to be studied in detail was the ability to choose correctly between alternative foods of differing nutritional value. This is called *dietary self-selection*. It has been studied in albino rats, but there is some evidence that, as would be expected, wild rats possess it too.

It is, of course, well enough known that animals generally eat just enough food to maintain a roughly constant weight or, in the young, a fairly steady rate of growth. Rats can also adjust their food intake in accordance with their need for salts and for vitamin B_1. They are not infallible: they cannot, for instance, respond in this way to deficiency of vitamins A or D. But on the whole it is true for rats (and probably for children if they are not badgered) that "a little of wot you fancy does you good".

How do rats distinguish foods of different value? Have they an innate ability to respond to certain food materials? We know that they prefer certain flavours (for instance, sweet ones) and reject others (such as that of aniseed), and that these preferences are probably independent of experience. But this does not account for dietary self-selection. In laboratory experiments it is found that selection of the "correct" alternative is aided if it is labelled, so to speak, with a distinctive

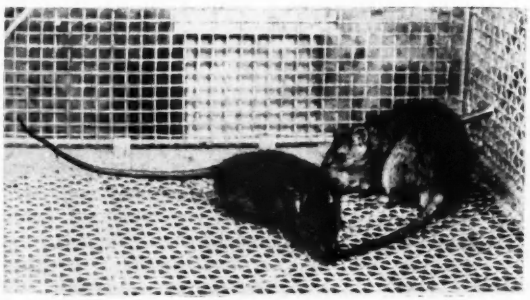

FIG. 1. The two species: on the left, *Rattus rattus*, the typical black form; on the right, *R. norvegicus*, the "brown" rat.

FIG. 2. An adult rat investigates a pot of flour during a feeding experiment. There is sugar on the right, wheat on the left.

flavour (the flavouring substance having no food value). It seems that a rat comes to associate a particular flavour, or a particular food source, with a "feeling of well-being" derived from the beneficial component of the food; and so it feeds more from that source. Evidently, only some necessary foodstuffs evoke a feeling of well-being soon enough after being ingested; others produce a delayed physiological effect, and to these rats cannot learn to respond.

In view of this, it is not surprising that rats also learn very readily to associate injurious effects with poisoned foods. If they eat a small sample of poison bait and recover, they will often refuse that bait—and even its component materials—if offered again. This is dietary self-selection the other way up.

I have referred to the eating of a small sample of a food. In most accounts of feeding behaviour it is taken for granted that rats will soon find food put in accessible places within their "home range". That this is justified is due to the remarkable propensity rats have for exploring their surroundings and sampling everything edible within it. It is not merely that they explore when they are, say, hungry or thirsty: indeed, if they are hungry, and there is food in a familiar place, they will eat their fill first, and explore afterwards. If in their peregrinations they then find more food, they will probably eat a little of that too.

Exploration is important for rats, not only for the finding of new sources of food and water but for the learning of the general topography of the locality. Rats in an established colony can take cover or escape to their homes at great speed, and so are relatively safe from predators such as hawks, owls, dogs, and men. Exploratory behaviour is a constant feature of rat behaviour, in young and old, male and female: even familiar ground is regularly revisited, so that the effects of previous learning are continually reinforced.

"NEOPHOBIA"

It might be thought that the ceaseless investigatory behaviour of rats must often get them into trouble, especially where their principal competitor, *Homo sapiens*, is laying traps. They are, however, protected by another behaviour pattern, highly developed in wild rats but not in laboratory-bred albinos. This is the avoidance of new objects. If anything unfamiliar is placed in a familiar area it is at first avoided; sometimes a large area around it is avoided too. When the new object is a trap or a heap of poison, this creates an impression of cleverness on the part of the rats. As a rule, the avoidance is only gradually overcome; in the early stages, if the novelty is a food, small samples are eaten.

Most of the movements of rats are consequently a resultant of two main behaviour components: first there is exploratory behaviour and the topographical learning which it makes possible; second is the opposed neophobia, as we may call it—the avoidance of novelty. (The resemblance of this second type of response to the behaviour of some human beings is purely coincidental.)

The preceding analysis is admittedly an over-simplification. Other conditions influence the movements of rats. Rats tend to move under cover rather than in the open, and in contact with a vertical surface such as walls rather than not. Against that, the stimulus of a possible mate or of an invading stranger may make a rat ignore all such considerations while it concentrates on copulation or fighting.

RAT POPULATIONS

The last sentence introduces the other principal aspect of a rat's life: its relationships with other rats. Research in this field has been largely concerned with conflict. Perhaps this is a reflexion of current human attitudes. We shall see shortly that amicable behaviour is quite as important, though less spectacular.

The "intra-specific competition" of wild rats was first encountered in work on rat numbers. If a few rats enter a favourable environment they multiply until a maximum is reached. What determines this maximum? In principle, it might be the activity of predators. It might be the food supply. Conceivably, it could be a rise in the incidence of infectious disease. Again, the availability of shelter, especially for parturient females, might be important. All these are, or can be, *density-dependent* factors: that is, factors which bear more and more heavily on a population as its density increases.

It has been shown that in some conditions the limitation of rat numbers depends on the distribution of the food supply and of shelter, combined with yet a further factor, namely, a tendency for rats to attack other rats entering the area around their nests. If rats are trapped alive and are released in the area of another rat colony, most of the newcomers die or return to the original areas. Part of the explanation of this is suggested by an experiment carried out by J. B. Calhoun. Rats in a large enclosure were given a single central source of food (which was always kept replenished), and nesting sites around it at different distances. The rats nesting at the periphery had to run the gauntlet of the inner rats whenever they visited the food, and these outer rats grew less, were less fertile, and had a higher mortality. It seems that, as a rat population increases, conflict among the members of the colony is likely to grow, and to become very intense once a certain density is reached. Just what density can be achieved will depend in a complex way on the quantity and distribution of food and shelter.

These facts suggest that rats are *territorial* animals. A territory is an area defended against other individuals of the same species. The defence may be by an individual, a pair, or by a group—a flock, herd, or shoal. Such defence is widespread among vertebrates: it has been especially studied among birds and among a few species of fish. Its function probably varies with the species: it may be a means of ensuring that populations do not overrun their food supply; it may help to create good conditions for reproduction; or perhaps it is a way of promoting dispersal. There is evidence of territorial behaviour in many species of mammals, but very little information on the precise character of the behaviour involved. The rest of this article gives some of the

results of a detailed study of territorial behaviour in the common rat.

MALES IN CONFLICT

If adult male rats, strangers to each other, are put all at the same time in an unfamiliar enclosure or large cage, they may settle down with little or no conflict and live together without death or injury. This has been observed even in experiments in which males of both species, *R. norvegicus* and *R. rattus*, were put together. Conflict does sometimes occur in all-male colonies: it is increased if, instead of putting rats in a cage at the same time, an interval of, say, ten minutes is left between the entry of each rat. It seems that conflict is likely to result when a rat already established in an area (even if only for a few minutes) encounters a newcomer. Fighting does *not* occur if one rat robs another of food, although this is a frequent occurrence in some conditions.

The territorial effect is clearer when a male is put in an established colony. Such a male is soon attacked, and if it cannot escape it is unlikely to survive.

In *R. norvegicus* all this fighting is the prerogative of the males. Females do not fight, except in a mild way reminiscent of play; nor are they attacked if they enter a colony of strangers. (They defend their nest when it contains young, but by gestures and squeals rather than by fighting.) However, *R. rattus* of both sexes are subject to attack if they enter *norvegicus* territory. Male *norvegicus* sometimes exhibit an ambivalent attitude to male *rattus*: they may at one moment make sexual advances as if to females, at another, attack them. Probably the stimuli concerned in the social responses of rats are mostly olfactory, and the smell of some *rattus* males resembles that of *norvegicus* females.

THE INFLUENCE OF FEMALES

Is there any motive for fighting among rats, other than the defence of a territory? If, instead of starting a colony with males only, females are included as well, there is a marked increase in discord among the males. In the first of a series of such experiments the colony consisted initially of six adults of each sex. After a few weeks the females were still alive and healthy, but only one male remained—the largest. It has usually been assumed that male rats fight over females in oestrus, and results of this sort seem to confirm the assumption.

However, further and more careful observation has shown that the assumption is probably false—another example of concealed anthropomorphism. If a group of males with an oestrous female is watched, they are seen to concentrate almost exclusively on copulating with the female: they do not fight. There may be slight scuffles, but these seem to arise only incidentally when one pushes another out of the way or becomes confused or over-excited and tries to copulate with another male. Contrary to some accounts, there is no pair-formation in rats and no elaborate courtship. Rats are completely promiscuous.

Further evidence comes from the effects of adding females to stable and peaceful all-male colonies. They remain stable and peaceful.

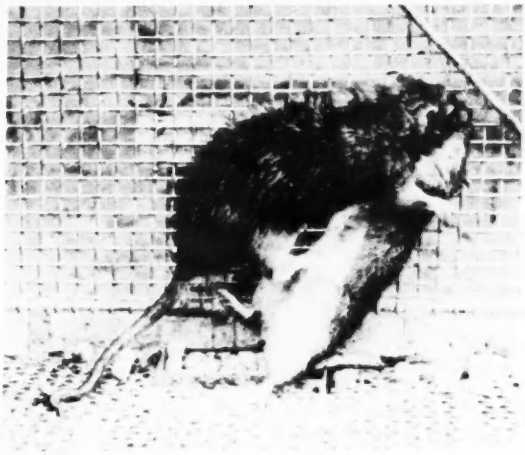

FIG. 3. Attack!

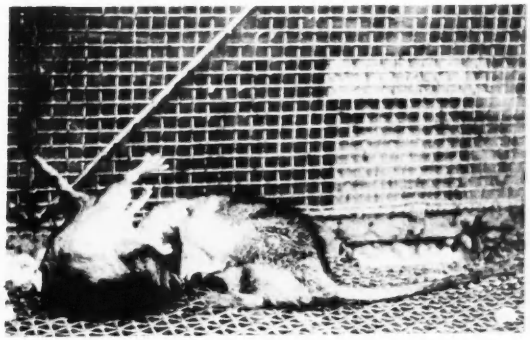

FIG. 4. Both fall.

There is no final explanation of these apparently paradoxical results. It is possible that fighting between males occurs only in a "territorial situation": that is, when one male is established in a particular area and therefore responds aggressively. On this hypothesis the increased fighting in colonies of both males and females represents merely an exacerbation of aggressiveness which would exist anyway. The failure of females to cause trouble when added to a peaceful all-male colony reflects the absence of strife among males which have achieved social equilibrium.

But why should females make aggressive males more aggressive, if they do not actually fight for or over the females? It is possible that the explanation can be found in the concept of "displacement behaviour". If an animal is prevented from performing a particular act, such as copulation, it may instead carry out some other stereotyped response, such as nest-building or preening or grooming. The alternative activity may seem to be quite irrelevant to the situation and is often performed in a perfunctory or hurried way. Anthropomorphically

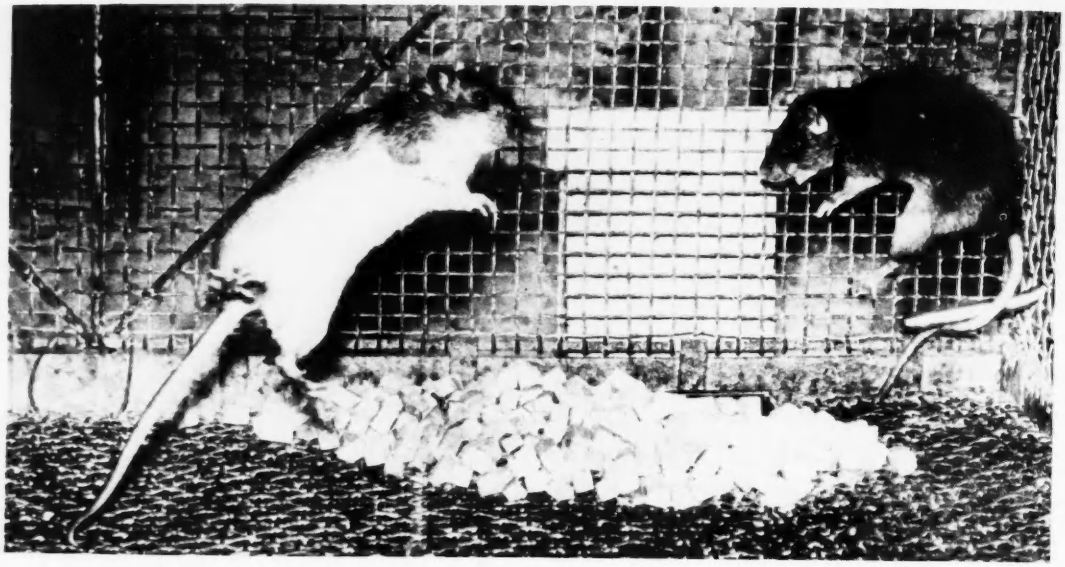

FIG. 5. A fight between a "brown" rat, *R. norvegicus* and a member of the smaller species. Both leap wildly in the air.

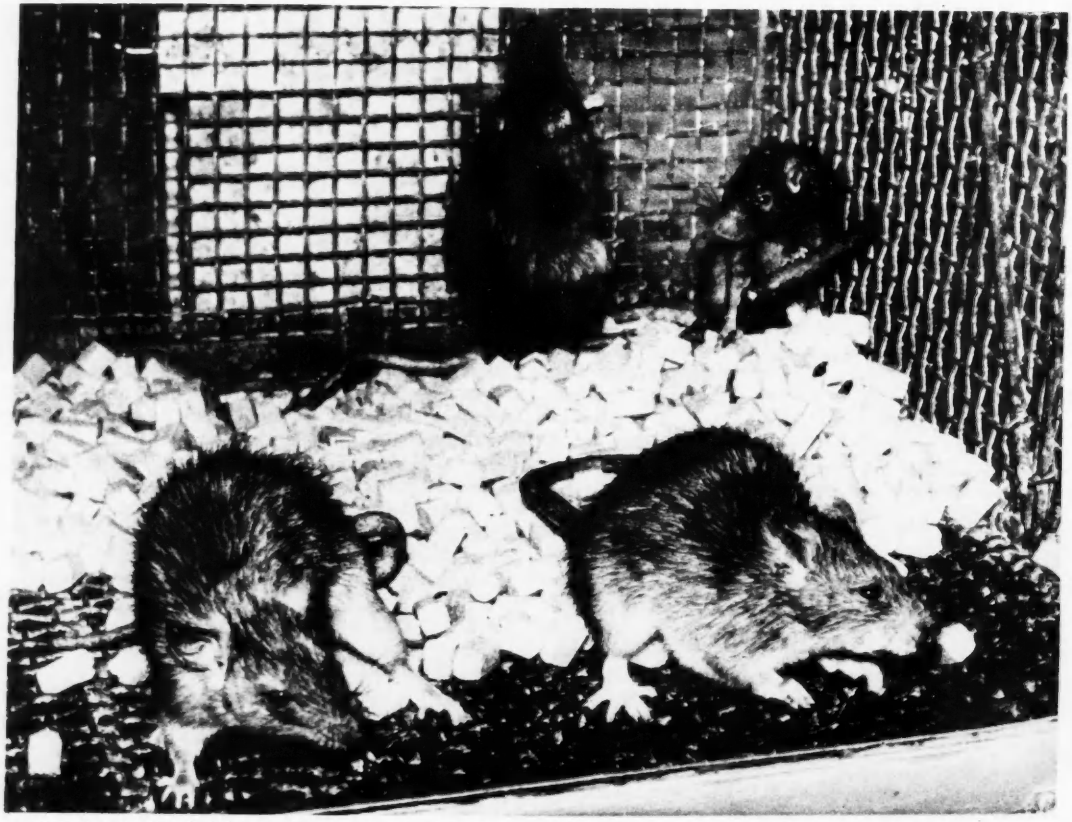

FIG. 6. A pause in a fight between the two species. In the foreground on the left is a brown individual of the miscalled "black" rat, *R. rattus*. On the right is an ordinary *R. norvegicus*. In the background two "black" rats which actually are black.

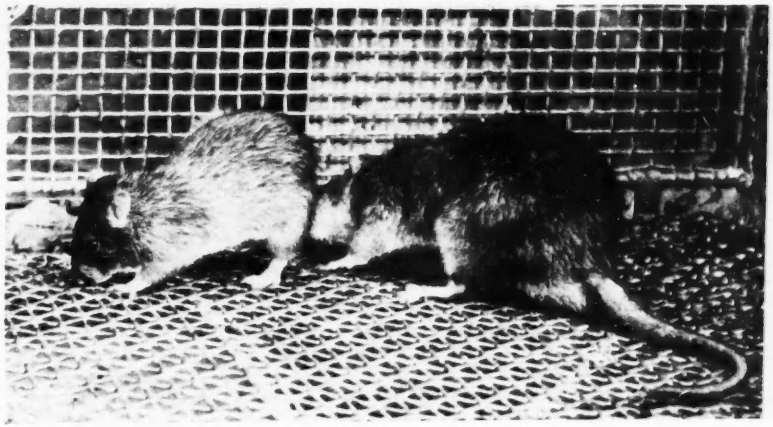

FIG. 7. A male hopefully investigates a female shortly about to come into oestrus.

speaking, it is as though the animal is "relieving its feelings". When male rats are living with a small number of females they are frequently aroused sexually and then baulked because the female responsible is not receptive. The hypothesis, then, is that the extra fighting in mixed colonies is a form of "displacement fighting". Whether and in what sense this is true must be determined by further experiment.

FIGHTING AND DEATH

Other problems arise from the study of the fighting of rats. The behaviour usually called "fighting" is, in species other than our own, usually harmless: typically, conflict between members of the same species takes the form of visible displays or audible performances such as bird song, roaring, or the howling of some apes; odours, too, may be employed. The effect of these so-called threats is commonly the retreat of one of the participants—unhurt but "defeated".

Rats, too, have their threat noises and postures. When an aggressive male rat on its own ground is approached by a strange male a first response is a chattering of the teeth; whether this constitutes a specific "sign-stimulus" for the strange male is uncertain. In a typical sequence the attacker next slowly approaches the stranger and adopts a peculiar posture in which the flank is presented to the stranger and the back is maximally arched; this may be called the threat posture. While in this attitude the rat may move in short steps round its opponent, always presenting the flank. If this is done to a member of the resident colony of similar size and status the second rat, too, may adopt the threat posture: there is then some mutual barging and prancing, and probably nothing more; the two rats eventually part with no harm done. But when the second rat is a stranger, threat is usually followed by actual attack: the first rat leaps at the stranger and nips with its teeth, as a rule at an extremity—foot, tail, or ear.

It might be supposed that such attack must often lead to severe injury, and that this must account for the death of interlopers. This is not the case. Severe wounding is very rare; superficial gashes are common, but rats can survive much worse damage, such as the loss of most of the tail or even of a limb. On the other hand, some rats subject to attack die without any visible wound or internal bleeding whatever. Death, one is tempted to say, is from shock—which means nothing except that the cause is obscure. The victor in a battle shows no sign of shock or exhaustion, however energetically he may have been fighting.

If rats survive persecution for some days they lose much weight, and examination after death shows that

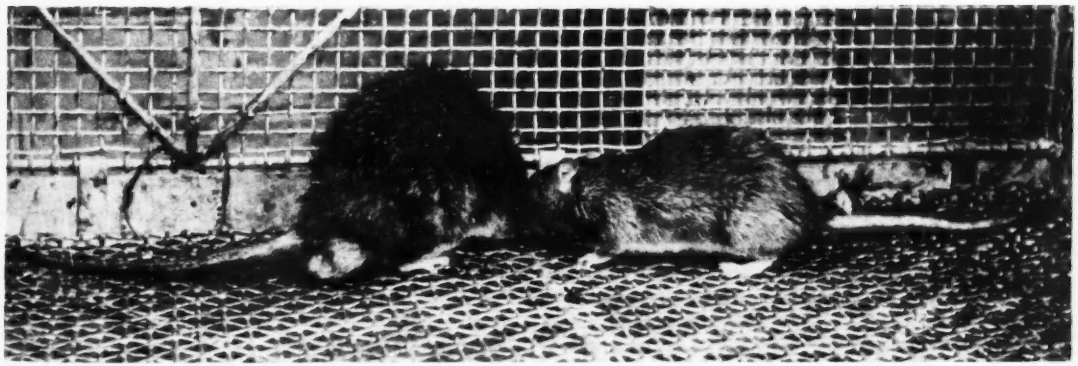

FIG. 8. A female in oestrus applies a gentle stimulus to the male.

their abdominal fat is at a minimum. This suggests that starvation, due to being kept away from food, might be the explanation. But death under attack may occur in only a few hours: the shortest time recorded is ninety minutes. Hence starvation can often be ruled out.

Stranger still is the fact that wild rats can be handled by an experimenter (one should wear gloves) without showing any signs of "shock". They resist handling vigorously but, once released, behave normally.

Outside the laboratory it is probable that severe fighting and death due to it are relatively rare, since rats under attack have more scope for flight. Presumably conflict is at its worst either when rats have been disturbed so that there is much invasion of strange territories, or when population densities are high. It is probable that many natural rat colonies consist of a single pair and their descendants; up to a point at least, the members of such a family would not come into conflict.

AMICABLE BEHAVIOUR

The last sentence introduces the topic of the cohesive forces in rat societies. After all, rats are notably gregarious: they live in colonies, often large ones, sharing the same burrows and feeding grounds. It is therefore to be expected that their behaviour should include elements which tend to bring individuals together rather than to drive them apart.

Indeed, the usual response of one rat to another—even another of different species—is to associate with it. As this is being written an experiment is in progress in which three *R. rattus* are together in a cage with two *R. norvegicus*. Three nest boxes are available, but all five rats rest and sleep together in one of them.

Rats are very markedly "contact animals". Tactile stimuli play a major role in the gregarious behaviour of rats, and there is one behavioural act which does seem to constitute a specific signal that the performer's intentions are friendly. In this, one rat quite simply crawls under another.

Some rats display amicable behaviour even in circumstances in which aggression would be expected. An example was provided by one of two males living together in a large cage. One, the larger, which we may call the alpha, had defeated the other, the beta, in battle. The beta had survived; it lived in its own nest box, keeping out of the way of the alpha. On the introduction of a third male the beta usually emerged first and, instead of attacking, behaved in what in human terms would be called an ingratiating way. Its aggressive propensities had evidently been suppressed by previous experience. The alpha, by contrast, dealt drastically with all newcomers—except females of its own species.

This example illustrates not only amicable behaviour, but also the fact that rats may show the phenomena of dominance and subordination which are very common among gregarious vertebrates. In some species there is a regular *dominance hierarchy* or "peck-order" (derived from the behaviour of domestic fowl); but this is not the case among rats. There is no fixed social pattern in a rat colony and, where the colony consists of a single family, there may be no dominance at all. In small experimental colonies there may be several alphas, each of which will attack newcomers; there may or may not be subordinate rats (betas) as well.

There is much variation of "personality" among rats, as the example of the alpha and the beta above suggests. This variation is evidently determined in part by individual experience. It increases the interest of the study of rat behaviour, but renders it more difficult to make valid generalisations on the subject.

CONCLUSIONS

Despite the reference to personality in the last paragraph, it must not be thought that the behaviour of rats can tell us anything directly about the behaviour of human beings. In particular, the social behaviour of rats is not only very limited compared with ours, but consists largely of quite stereotyped responses to the stimulus of the presence of another rat—male, female, young, or of another species. Individual differences depend primarily on variation in the extent to which one pattern of behaviour or another is the more conspicuous: for instance, whether aggression or submission is most highly developed.

The behaviour of wild rats illustrates the importance of exploratory behaviour and of topographical and associative learning; these, together with an adaptable digestive system, make possible the dietary versatility of rats. Avoidance behaviour or the suspicion of novelty constitutes the protective counterpart of exploration. Social behaviour includes the elements of gregariousness and corresponding amicable behaviour; these cohesive influences operate even between members of different species. Disruptive activity is evoked only in specific conditions: it is shown only by males, and by them perhaps only in territorial situations. There is no satisfactory evidence for fighting over females, and much against it. The presence of females may in some circumstances make territorial fighting more intense. Fighting rarely leads to severe wounding; but the vanquished may die, as a result of a form of "shock" which requires much fuller investigation.

The facts of the behaviour of rats, reported without prejudice, do not give much encouragement to those wishing "to point a moral, or adorn a tale". Nor do they support notions about superhuman abilities or mysterious instincts. They do, however, show how much we have to learn about even the most familiar of our fellow-mammals.

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Skeleton of a calf against a lonely landscape of drought in Australia. (*Photograph by Sidney Nolan.*)

THE FUTURE OF DESERTS

RITCHIE CALDER, C.B.E.

A desert is best defined nowadays as "a deserted place". If we choose to ignore, neglect, or abandon a region—that is a desert; if we choose to intervene and take an active interest, it will not be a desert although it may still be an "arid zone". This is more than a matter of definition; it is an important revision of our attitude. We have acquiesced in the idea that certain regions are useless. Our geographers have tended to "write them off" and our cartographers to leave them as blank spaces in our atlases.

When, only seven years ago, I was travelling for UNESCO in the Sahara, and sending back dispatches which were being followed by children in school, I had to give latitude and longitude for my points of departure and arrival because none of the conventional maps could identify the places by name. The children had to compile their own maps, from my direction fixes and my identifications. Today, when the French are trying to convince investors that the Sahara is not really a desert but indeed a piece of desirable estate, with rich reserves of oil, coal, iron, manganese, copper, lead, uranium, tin, and chromium, obscure water-holes are now writ large, if not in the atlases, at least, in the prospectuses. "Ains" (wells), "Oueds" (waddhis), and "Chotts" (marshes), which I knew by word-of-mouth, now warrant black-faced type.

The sand-whispering solitudes of the Hoggar Mountains, once sinisterly romanticised as the secret places of the veiled Touaregs, now respond to the clicking of Geiger counters. That "mirage" of a Bedouin, in a burnous, on a bicycle, which I followed to the coal-mine at Kenadsa, has materialised as the desert miners now producing three hundred thousand tons of coal a year.

The camp-fire predictions of the geologist from Oklahoma who prospected the Sahara for two and a half years have been confirmed by yielding oil wells. The geophysicist who, as we waded through the hot, burning sands of the *Erg Cheche*, insisted "we are walking on water", has been certified sane by events; a great underground reservoir, the *Albienne Nappe*, a nodular sandstone aquifer, is known to extend for a great distance under the Northern Sahara; there is evidence of further extension south and under Tunisia and into Libya.

THE WORK OF UNESCO

The recognition of deserts as "desirable sites for development" is not confined to the French Sahara. Apart from the intense activity in the Israeli Negev, and the irrigation schemes for Iraq, there has been the substantial reclamation of deserts in Pakistan and India and, of course, the large-scale recovery of deserts in the Karakum and Trans-Ural regions of the Soviet Union. Everywhere in the world deserts are now being looked at with fresh attention. This is in a large measure due to the work, not sufficiently well known, of UNESCO. This organisation concerned with research rather than the practical development of deserts (which is the proper function of the Food and Agriculture Organisation) has focused attention on those areas of ignorance.

After seven years of discreet but thoroughly rewarding work by its "Advisory Committee on Arid Zone Research", the recent general conference of UNESCO at New Delhi has made "Arid Zones" a major project for the next two years. With more money available, the exploratory work will be extended and advanced in the desert regions. Help is to be given to institutes at Heliopolis, in Egypt; at Beersheba, in Israel; and at Ankara, in Turkey. But the work which has already been done deserves greater recognition than it has so far had. UNESCO has called on experts in various aspects of the desert problem from all over the world. By special studies and by symposia, UNESCO has brought together the knowledge of the experts, and the experts themselves, to discuss and to share their common problems and to relate the experience of one desert region to another. The latest of these "reviews of research" is "Human and Animal Ecology" (available at 25*s*. through H.M. Stationery Office). This, however, is only one of the series. The literature produced at the instigation of the Advisory Committee includes (1) "Arid Zone Hydrology"; (2) "Proceedings of the Ankara Symposium on Arid Zone Hydrology"; (3) "Directory of Institutions Engaged in Arid Zone Research"; (4) "Problems of Utilization of Saline Water"; (5) "Plant Ecology: Proceedings of the Montpellier Symposium"; (6) "Plant Ecology: Reviews of Research"; (7) "Wind and Solar Energy: Proceedings of the New Delhi Symposium"; as well as "The Future of Arid Lands", published by the American Association for the Advancement of Science, the assembled reports of the meetings in America, which UNESCO sponsored and for which it provided travelling funds.

These are publications of immense importance, not only to the scientists engaged in the various fields involved, but to geographers and to economists. New research has been initiated or encouraged, and existing knowledge has been gathered in. Apart from promoting direct activity in countries where the problems are economically acute (as in Israel), the work of UNESCO has stimulated scientific inquiries into "novel" problems ("novel", because they have so far been overlooked) and has made experts revise many assumptions which have existed about climatology, arid soils, desert plants, human activities, and animal husbandry.

SOLAR ENERGY

No one familiar with the hot deserts can be casual about the possibilities of solar energy. Many useful devices have been proposed and are being promoted to make use of solar energy, but none which can effectively employ the vast amount of radiation of which one is acutely conscious in the deserts. As a French scientist said to me as we blistered under a cloudless sky: "There", pointing to the sun, "is our nuclear reactor." The plans for the new desert research institute at Beersheba include cooling and air-conditioning by use of the sun's energy. If the so-called "Nehru Stove", the reflector device developed in India for cooking purposes, could be produced at a price low enough for the impoverished Indian peasants, the use of "solar fuel" would mean that the dung now used for burning could replenish the undernourished soil. The Russians have ambitious plans for a solar energy electricity generating station in the region of Mount Ararat.

No one who has seen oases shimmering with glistening crystals and dying under the crust of salt, can underestimate the importance of desaltification. The repeated tragedy of finding water in the desert is its saline content. This is often a degree of salting which does not make the water unpalatable or useless for irrigation; except when we remember the high evaporation rate under the hot sun; which means that any fraction of salt continuously aggregates in the soil so that any degree of salting in time becomes poisonous.

DEW

There is a new awareness of the importance of desert dew,* which meteorologists (but not the Old Testament) have tended to under-estimate. The dew mounds at Subetta in the Biblical Wilderness are a reminder that the Ancients realised the practical value of dew. These mounds are piles of pebbles which in ancient times were loose. The dew condensed on the cold pebbles, filtered through into the soil, and the mounds themselves acted as a parasol against the heat of the day, keeping a moist "sump" of soil in which plants rooted and provided the groves of the ancient city. With these reminders, considerable research has now been done into the nature and behaviour of dew in the desert with promising results. It is now known, for instance, that certain plants are "dew-gluttons", which absorb the atmospheric moisture through the leave- and secrete surplus moisture

* An article by the eminent Israeli dew research worker, Dr Sh. Duvderani, will appear in the next issue of DISCOVERY.

into the soil. One of the possibilities which has been raised is that of using such plants as "wet-nurses" for other plants.

DESERT SEEDS AND PLANTS

The researches and symposia have encouraged interesting experiments into the character and behaviour of desert seeds and plants. One of the fascinations of the desert is the great burst of vivid-coloured flowers which will spring up after a shower of rain in regions which have been rainless for years. Another strong impression one gains in travelling, or flying, over deserts is the pattern of growth of desert trees and shrubs. One notices that around an established deep-rooting tree or shrub there is an area where no other vegetation appears. The obvious assumption is that the established plant has monopolised all the moisture and any competing plants have died for lack of it. It has, however, been shown that such plants give off an inhibitor which, without destroying existing seeds, prevents them from germinating. Given enough rain to wash out the inhibitor, there will be enough soil moisture both for the established plant and for the latent ones, which will grow. It has also been shown that desert seeds have a chemical coating—a mackintosh—which prevents them from germinating until there is enough water to help them to maturity. If there is merely a skirmish of rain, insufficient to remove the entire coating, the seed will regenerate the protecting chemical and will "go to sleep again" until there is enough rain totally to remove the coating. This suggests all kinds of possibilities of revegetating the desert by broadcasting seeds protected in this way—to await the occasional rains which will establish them.

WATER CAPITAL

Always, of course, the paramount problem in the desert is water. Here the hydrological inquiries and symposia, organised by UNESCO have brought together a knowledge, old and new, about the surface water and ground water in arid regions. One of the paradoxical conclusions emerging is that surface water is not something you should encourage in desert conditions. There is the familiar example of the waddhis, the streams which come down in periodic spate, not as tributaries to lakes but as evaporating pans—spreading the water over the desert to be immediately evaporated. But it has also been shown that a water-table five to ten metres below the ground will lose as much by evaporation as though the water were on the surface. The losses from a high water-table, in an arid region, are enormous. Therefore, against common belief, it is beneficial rather than otherwise, to lower the water-table so that it is beyond the reach of the sun's heat. This has intensified the studies of ground water at depth. It is estimated that the amount of water underground is ten times that which is available on the surface. These underground water sources are not just the springs replenished by the "income" of seasonal rainfall, but are the stores of water "capital" which have been accumulating not only over the centuries but in some instances over millions of years. "Water from depth" therefore becomes one of the necessary inquiries to precede desert development.

Water beneath the ground, however, is quite useless for practical purposes until it has been brought to the surface when the factors of evaporation operate. The Ancients, in Roman and Byzantine times, met this by underground rock cisterns. Moderns have to rely on open reservoirs from which the evaporation loss is very high. There was an ingenious early proposal to use nylon flakes to cover the surface of reservoirs and reflect the heat of the sun. The difficulty with this, as with other ideas, is that the effect is destroyed by winds. The Council for Industrial and Scientific Research in Australia seem to have found an answer by the use of cetyl alcohol, using a monomolecular layer to cover the surface of a reservoir. Even on large surfaces, like the Broken Hill dam, they have succeeded in maintaining the layer in spite of wind movement, and over a period of fourteen weeks in the heat of the Australian summer saved the equivalent of six weeks water supply for Broken Hill. If this, or some similar cheap device, can be developed for practical use throughout the Arid Zone, it will radically alter the problems of storage and irrigation.

THE MISTAKES AND GREEDS OF MAN

One-third of the earth's surface is arid, in terms of climate or on the basis of natural vegetation. If the climatic limitations can be removed by man-made water systems, large tracts of this "deserted" region could be reclaimed for human food-growing and for development. But throughout that region we have the age-old reminders that deserts have been created by the mistakes and greed of Man. It is, therefore, all the more important that this patient and thorough research and investigation which UNESCO has promoted should enable us to avoid the mistakes of haste and over-optimism. Here, on a world scale (because every continent is afflicted with deserts), we have the bringing together of experience and experiment to ensure that deserts will be developed in wisdom.

THE PHILOSOPHY OF SYNTHESIS

A. GODFREY CRUFT, F.C.I.S., F.I.I.A.

Two or three years ago few men had heard the word automation and it may be that nobody was worried about it, but today it is probable that no other aspect of modern industrial activity has attracted so much attention. This is for many reasons unfortunate. The word was coined and applied to what was an inevitable and logical development of mechanisation, and the application of electronics to automatic control of batch and flow production techniques. It connotes an integration of machines with one another into fully automatic and in some cases self-regulating systems. It is the continuation of a process; it is not in itself a revolution. But popular journalism has extended the connotation of the word to embrace even the most simple of mechanical devices, and one recoils from the thought of what will happen when *Cybernetics* is adopted in a like manner.

Nevertheless, despite problems of social and economic adjustment which will undoubtedly emerge, the growing importance of automation to Britain, if we are to maintain our prosperity and raise productivity, is manifest. This being so, it is deplorable that because a little temporary local dislocation may arise the introduction of this new term has resuscitated a measure of purblind criticism of everything scientific and mechanical.

THE FATAL DICHOTOMY

It would indeed seem that our lives today are in danger of being divided into compartments, some of which contain a considerable degree of specialist knowledge but all of which are surrounded by an impenetrable maze of ignorance and irrational bias. There is, however, more in this than mere academic interest. The recent impetus to the study of scientific management, involving the introduction of advanced production processes, focuses attention on that fatal dichotomy which does so much to paralyse any real advance in the social sciences. This is well understood by many contemporaries who cry out against the tendency to segregate science into regions, and the paramount error of creating boundaries between science, religion, and the arts. Briefly and broadly, we need a balanced and unified culture and, as Dr J. Bronowski puts it: "A scientific education is a part of cultural education, because for lack of life-giving parts the ancient cultures are dying at the roots. . . . Science must become as a subject part of our culture or we shall fail, not to train scientists but to preserve our culture."

The Duke of Edinburgh, in his Presidential Address to the British Association for the Advancement of Science, meeting in Edinburgh in 1951, stressed the same fundamental need and emphasised that: "The pursuit of truth in itself cannot produce anything evil. . . . Progress in almost every form of human activity depends upon the continued efforts of scientists. The nation's wealth and prosperity are governed by the rapid application of science to its industries and commerce. The nation's workers depend upon science for the maintenance and improvement in their standard of health, housing, and food."

For myself, I am perhaps more enamoured of truth than convenience, but no one, I fancy, will deny that it is relevant to consider at this time how the present false attitude to science came about, and whether or not anything can be done to circumvent the sophistry.

NATURE CANNOT LIE

It is all very well for our inherently persuasive politicians to recognise this split-mind attitude to social problems and pay lip-service to the need for a mental revolution, but this alone does not explain how to break through the departmental barriers which frustrate much of our national effort.

Francis Bacon held the view that "God has placed no limits to the exercise of the intellect He has given us on this side of the grave", but it is the fashion nowadays in some quarters to sanctify ignorance and emotional prejudice as God-like qualities, and to condemn all knowledge obtained by scientific method as the cause of all evil. We are, it would seem, living in two worlds; a world of facts on which our very existence rests, and a world of values based wholly upon emotions, sentiments, and prejudices which are in the main contrary to those facts.

But facts are not man-made. They arise from the acceptance of scientific laws and principles which are universal; they do not exist merely for certain men, scientists, in certain special circumstances within their own specialties.

They are not laws designed by man to serve his own wicked ends in opposition to *the will of God* or *the function of Nature*. On the contrary, they are man's endeavour to interpret God's design (the physical universe) to enable him to restrict or extend the activity of his life in accordance with those inexorable laws.

There is no lie in nature, and scientific method implies the direct appeal to nature for truth instead of to authority. It enjoins us to be critical of all things; it requires of all who claim to have discovered truth that the onus is upon them to prove their claim rather than upon others to disprove it—unlike the judicial law, all is false until it is proved true; it demands constant experiment under rigid control conditions, and it requires a positive result in every case before we can claim to have discovered knowledge; it recognises no finality. Questions in plenty press upon us, questions to which no final answers can be given, but it is surely clear that in the search for knowledge and understanding the application of scientific method should be invariable. It should come as much into art and religion as into the factory and the laboratory.

RELUCTANT SCIENTISTS

Most of our troubles today can be traced to failure of the social sciences to keep pace with technological advance, and our inability to apply these same universal

laws and principles to the living situation. In the social sciences, institutions rather than reason are in the saddle and men and nations are reluctant, and indeed lack the courage, to be critical in matters affecting their own passions and personal preferences. Theory and practice are seldom in the hands of the same individuals, with the result that a comprehensive gibberish has been evolved completely out of touch with daily life. This applies particularly in the field of economics. Few business men understand the elementary laws of the *science*, with the result that they practise blindly; while few economists have ever managed anything, with the result that much of their preaching is futile and unreal. The circumstances in relation to psychology are similar.

We can, it is true, draw a degree of dubious comfort from the realisation that beneath all differences there subsists a common moral and ethical stock strong enough in the long run to check extravagance.

But what is the reason, we may ask, for the apparent reluctance on the part of some eminent scientists to acclaim the basic method which is the foundation of their knowledge? Unfortunately the cause is clear. The science graduate invariably goes direct from school to university and is soon immersed in his specific technical training. Through practice and by implication he acquires knowledge of scientific method in connexion with his own work, but he is not trained in that method or taught to understand that it should be universally applied. The result, more often than not, is that beyond the confines of his own discipline he is influenced entirely by his sentiments and emotions, and when these are aroused he is often no more logical than those of us with no training at all. He should be guided to an appreciation of the interdependence of all branches of science upon one another and the dependence of them all upon principles of scientific method.

NEED FOR LIBERAL EDUCATION

Much attention has recently been given by educationists to the need for liberal technical education, but what is even more important is that any liberal education should include acquaintance with the principles and laws of science. There is a dominant need to liberalise the arts, and we must look forward to the time when ignorance of primary laws and facts of science will be "looked upon as a defect second only to ignorance of the primary laws of religion and morality".

Prof. John Dewey pointed out that the "future of our civilisation depends upon an ever-widening spread and deepening hold of the scientific habit of mind". So far from being in conflict with religion, science should strengthen it. Our more recent knowledge, reaching out to ever-receding and expanding frontiers, reveals a reality more majestic and harmonious than anything conceived in the past. To quote Viscount Samuel: "By helping to simplify, purify, and enlarge our conceptions of the cosmos and of Deity, science may join in offering to modern man a faith than can satisfy his emotions and justify his innermost beliefs, without offending and alienating his intellect. This is not to destroy; this is to exalt religion."

In the field of adult education the same general theme has been uppermost in the minds of responsible authorities. Dr Eric Ashby recently went so far as to outline the present need for *technological humanism* and to advocate a course which would be a symbiosis of moral philosophy, art, and science. He clearly thinks that vocational study and the humanities should be integrated. Dr Ernest Greene, who has published the result of extensive research into the apathy connected with adult education, reported that many students are losing interest because the subjects taught are of no practical value in later life. It is now the more general view that liberal education should not stand in isolation from training and technique.

The issue is clearly discernible. Britain cannot hope to retain its present position in the world unless a more enlightened attitude of mind to scientific teaching is engendered. There is therefore a primary need for instruction in basic principles of scientific method. Any attempt to popularise science or to disseminate scientific information to the general public, here or abroad, will fail *unless and until specific training in scientific method is introduced in simplified form in the elementary-school curriculum*, and also as a preliminary to every university course of instruction. Neither science nor philosophy can operate in a vacuum.

Following the war there was much wishful thinking about the spread of scientific knowledge. The continuous flux of thought is encouraging but also disconcerting, and the truth is that many people still suppose scientific and humanistic studies to be antipathetic, representing opposing qualities. Despite some improvement, the same prejudice is evident, and it seems clear from an objective study of the situation that understanding of scientific method is our great need and our hope at the present time—or for that matter at any time. The ordinary man longs, in a vague sort of way, for an understanding of science. But it is absolute folly to fill his mind with small isolated bits of scientific information unless he is aware of the basis upon which science rests. He should be taught first things first. He needs to know what scientific method is, and be able to apply it at all times.

The following observations, written in 1946, are today much to the point:

Let us be clear what is science. Let us be clear as to what is man. Does he differ from lower forms of life because he feels emotions and can experience pleasure, sexual or otherwise? Is he different because he can exhibit irrational prejudices? No! Let us be quite clear that the way in which man differs from other mammals is by virtue of his greater brain capacity and because he is endowed with powers of association and reason. In this, and in this alone do we differ from the brute. The laws of science are not man-made but are man's attempt to understand the laws of God. Scientific knowledge is a modicum of knowledge of Eternal Reality. To ignore it or to refuse to make full use of it is to deny our heritage and our place in the evolutionary creation of which we are a part.

Today realisation of this is vital if we are to survive, and this can only come about if science *"to itself do rest but true"*.

A XVI-CENTURY MANUAL OF PYROTECHNICS

A. D. CUMMINGS

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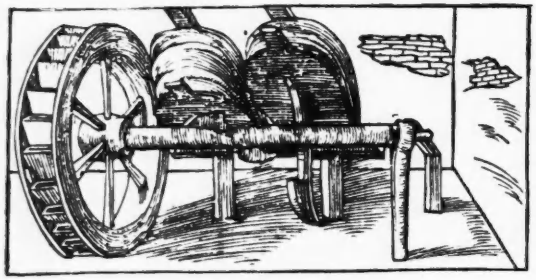
Since books were invented, words and pictures have always gone together. In writing about handicrafts and manufactures the need for some kind of illustration to supplement and clarify the written description was soon felt. The artist was called in to work with the writer, and the first illustrated "text-books" appeared.

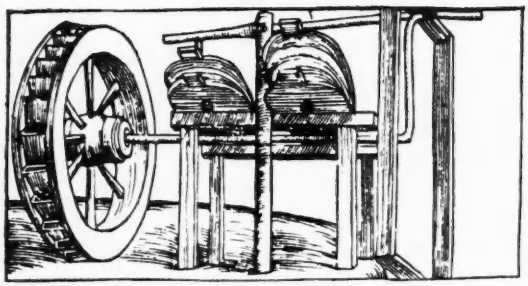
In the first hundred years of printing, the presses were kept busy with the many works that had circulated in a limited way as manuscript copies, there were books in plenty to be published, and probably even then publishing houses could pick and choose. Perhaps already they had rather fixed ideas as to what their readers wanted and what would sell. Whatever the state of the literary market in the 16th century, it is certain that technical writing had a very small part in it. Processes such as dyeing, weaving, mining, and smelting ores were well established, but the working knowledge needed for the carrying on of these trades had been handed on by word of mouth from father to son, from master to apprentice for about 5000 years before being disseminated in writing. We know that mining law existed continuously from Roman times, but the practice of mining and smelting apparently went unrecorded. Not all the men following these crafts were illiterate, but they left no records that have survived. These arts were performed in a few localities, where they reached a high degree of skill and their products travelled widely, but if any enterprising prospector found metals away from the known areas, the difficulties of starting an industry must have been almost insurmountable. He had to find a patron, a great landowner or banker, to finance him.

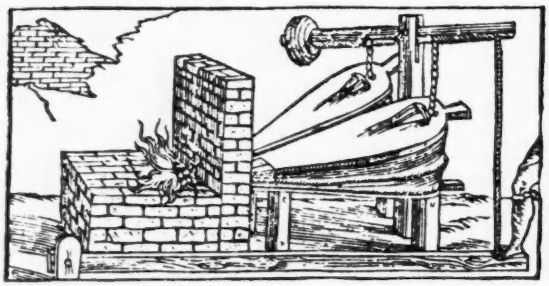
In the 16th century three books appeared, the first technical treatises. One of these—Agricola's "De Re Metallica" (described in DISCOVERY of July 1956)—came out in 1556. Another, Biringuccio's "Pyrotechnica", appeared in 1540, and Ercker's "Treatise on Ores and Assaying" in 1574. All three books are illustrated and have been translated into English in recent times. All three authors write of a trade that had already been brought to considerable perfection. As the translator of two of them remarks, even though the laws of chemical combination were not discovered until 200 years later, the truth of these laws was acted on practically. They could analyse a sample and forecast what an ore would yield in smelting.

VANUCCHIO BIRINGUCCIO

Vanucchio Biringuccio was born in Siena in 1489 and died in Rome in 1539. Like Agricola, he died a year before his book was published. During his life he worked chiefly as a cannon founder for a noble family of Siena, the Petruccis, for the republics of Venice and







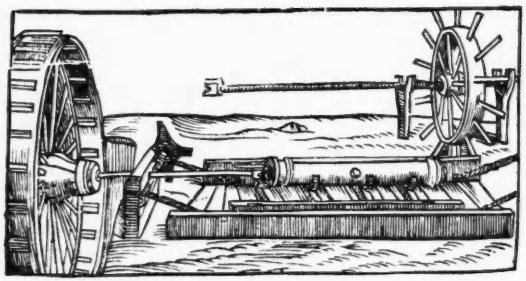


FIG. 1, a, b, and c. Illustrations from *Pyrotechnica* by Biringuccio, 1540, showing furnace bellows operated by water-wheel and by man-power. The stream of water turning the wheel has been omitted, as has the man from the last picture. They have been considered unnecessary details. FIG. 2 (*bottom right*). Making a mould for a gun.

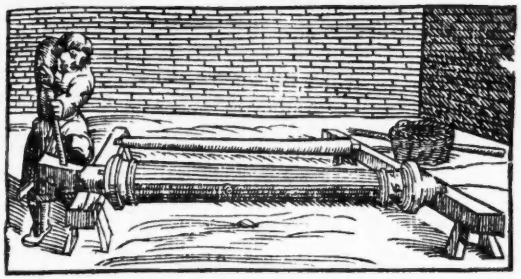


FIG. 3. Boring a gun.

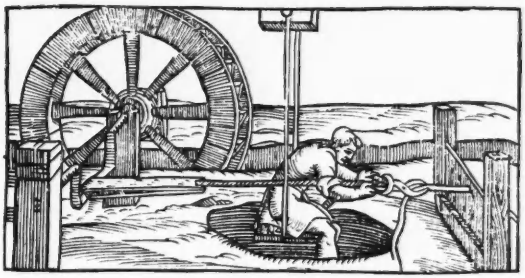


FIG. 4. Drawing of gold wire.

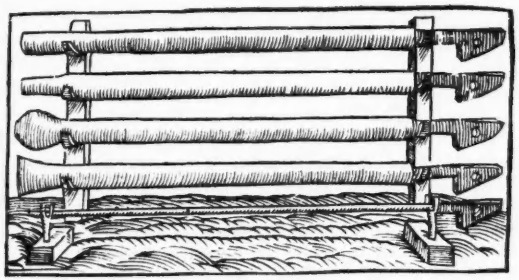


FIG. 5. Gun-boring tools.

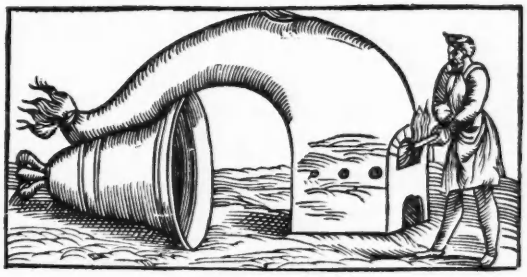


FIG. 6. Portable furnace for mending bells.

Florence, and for Pope Paul III. He was proud of his profession, says that it is worth anyone's serious attention, and warns off dilettantes who might think that working with metals is easy. In the course of his studies he travelled in Italy and Germany, and he must have been familiar with the metal-working centres described by Agricola. The latter seems to have been the cleverer man. He writes in a more scholarly style, but often tells us three or four ways of doing the same thing without conveying the conviction that he knew which was the best. Biringuccio, on the other hand, gives us the impression that he was essentially practical; the processes he describes sound as if they would work. Both men were sceptical of alchemy and ore-finding methods involving the use of magic. Biringuccio's motto for running a smelting-works was: "Weigh everything and trust nobody but yourself."

He deals first with the discovery of ores and the siting of a mine. He goes on to deal with cleaning and smelting the ore, but the sphere in which he seems to have most first-hand knowledge is the casting of bronze bells, cannon, and, to a lesser extent, statues. He tells you frankly, "I have done so-and-so and had good results," or "I have heard that other masters do so-and-so, but I cannot speak, as I have no experience." On the whole, his methods do not differ from those still in use. What he says about the careful selection of moulding-sand and the making of the mould is still sensible, and his "lost wax" method has been revived.

Guns were at that time cast in a mould built up in three pieces: barrel, breech-piece, and casting-head (the muzzle and a projection beyond it). A solid pattern of the gun was first made in wood. Over this a mould was built, of prepared clay mixed with fibres, strengthened on the outside with iron wire and bands. This was dried in warm air and the wooden pattern knocked out. Separate clay moulds were made for the head and the breech-piece which closed the gun at the butt. The complete gun-mould was now assembled in a vertical position in a pit below the furnace. A core to form the barrel (built up from clay and wire on an iron rod) was inserted centrally and held in position with keeper-rings. All parts were held firmly together with iron bands and supported in the pit. The mould was now ready to receive molten metal from the furnace. This had to be fluid enough to fill the whole mould in one operation, and Biringuccio says that at this stage it might be necessary to add more tin. The metal was now run in up to the top, the idea of the casting-head being to give density at the top, or gun-muzzle, which might otherwise contain bubbles and be porous. When the metal was cool and solid, the mould was knocked off, the head was sawn off, the outside of the gun was cleaned and polished, and the barrel was bored truly cylindrical. He says, "To make it shoot with perfect accuracy, master-gunners begin to demand that both large and small guns should be bored. To this end I have made a large double wheel (i.e., a treadmill) so that a man could walk inside to set it in motion . . . in the socket of which I fitted an iron spindle long enough to reach to the end of the gun, at the top of this I had a piece of steel welded with all four corners true, sharp, and well tempered, so that when put into the mouth of the gun it made it exactly round. I have fixed the gun on a board of elm that was flat, made like a little cart and placed on a platform at least twice the length of the gun, with rollers beneath so that the gun could move easily when it was pulled by cords attached to a wind-

lass. I had the wheel turned with the force of three or four men. I fitted the iron shaft well into the socket, and by pulling with the windlass brought the mouth gradually near, and by turning made it go all the way to the end . . . thus, by repeating, each time increasing the cut of the steel square, I cleaned and bored very well." He tells us that for the siege of Florence in 1529 he made a gun for the Pope that was eleven feet long and weighed nine tons.

In a final section Biringuccio describes the making of gunpowder from charcoal, nitre and sulphur, and how to construct mines under fortresses, flame-throwers, and grenades, as well as fireworks for amusement on more peaceful occasions.

THE ILLUSTRATIONS TO BIRINGUCCIO AND AGRICOLA

It is probably because of the excellence of his pictures, quite as much as his literary superiority, that Agricola's book is the best known. There are about 270 illustrations, covering all sections of the metal industry and some chemical operations. It is obvious that he took pains to find a suitable artist and to instruct him carefully how to emphasise important details. These illustrations go beyond the immediate machine, and often include the landscape as well. Sometimes they are minor works of art, reminiscent of Dürer.

Biringuccio's illustrations, which he scarcely refers to, are small and poorly drawn. They are a guide to understanding the text, but often the artist does not understand what the apparatus shown is doing. Fig. 1 shows three ways of operating furnace-bellows. The artist has drawn no more than he has to: even a man is reduced to the one working foot, and the stream of water is omitted from the water-wheel. One bellows is clearly operated with a cam, but the rotating crank in another does not look as if it would work. The gun-boring machine referred to is shown in Fig. 2, with the treadmill on the left. It will be remembered that, until the invention of the steam-engine in the 18th century, only wind- and water-mills were available for mechanical power.

The first metal-workers learnt their trade from their masters. Often, indeed, it was a jealously guarded secret. But once books were available, even quite complicated ideas could be widely communicated and inventions could spread more rapidly. In this way these early books and their illustrators played a part in advancing technical skills.

TWENTY-FIVE YEARS AGO

AN IMPERIAL AND A GLOBAL NOTE

Our issue for July 1932 had an international flavour. First, we were not a little proud of ourselves:

"It is literally true that DISCOVERY is read in every corner of the Empire, and letters from overseas subscribers reach us from places as far apart as Brisbane, Australia, and the Fiji Islands. We believe therefore that this issue will be of particular interest to our readers in the Empire. We have always regarded 'stunts' as out of keeping with serious journalism, and we believe that DISCOVERY needs none of the attractions with which some of the newspapers beguile a trusting public."

These remarks, still true today, were prompted by the opening of the Imperial Conference which took place in Ottawa, and the issue has an Imperial flavour, with articles on "The Progress of Empire Research" by Sir Stephen Tallents, "The Five-Year Research Plan in Africa" by Lord Lugard, "Science and Empire Fruit Growing" by H. V. Taylor, "A Year in Northern Rhodesia" by Malcolm Burr, "Developing Empire Air Routes", "Wool Research in New Zealand", and "Bird Watching on an African Peak" by R. E. Moreau. Though the Empire in name and form no longer exists as it did in 1932, we believe that the ties between Britain and all these parts of the globe are as close as ever, and are maintained through genuine co-operation and understanding. In this month of July 1957, when the International Geophysical Year begins, we can look with hope to an even wider co-operation among scientists of all nations, who, whatever their political creeds, are brought together by a single aim: to discover more about the physical world in which we live.

One isolated item in our July 1932 issue deserves notice: an article on the televising of the Derby on June 1, 1932, from the Metropole Cinema, London. "The finish of the race was shown on the screen at the same instant as it was being watched on Epsom Downs. The experiment was the first of its kind attempted in any part of the world, and is a notable advance in television transmissions."

THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

Of all the many IGY activities in different parts of the world, the Antarctic is still the centre of the major effort. Preparations for scientific observations have been in progress there for well over a year, and at the official opening of the Year it seems right to summarise the present position as far as it is known.

Antarctic Perspective

On the whole the progress of all expeditions in the Antarctic has been satisfactory and in some cases spectacular. Scientific programmes appear to be on schedule, and all the IGY stations ready for observations to begin this July 1, with the exception only of Vostok (the Geomagnetic Pole station) and Sovetskaya (the station scheduled near the so-called Pole of Inaccessibility), and the Belgians', who started late. It is perhaps more worthy of comment that the establishment of the two Russian stations deep in the interior should have been attempted at all, than that the Russians have failed to reach them in mid-winter journeys undertaken by tractor-train.

Argentina. Last year it was announced that a station was to be established on Thule Island in the South Sandwich Islands, and that this would be a fully-fledged IGY post. But in January 1956 there had been a severe volcanic eruption on nearby Bristol Island which necessitated evacuation.

The main part of the Argentinian contribution to IGY Antarctic studies is to be in glaciology. At each of their Antarctic minor establishments a scientist trained in geology and glaciology and two assistants will join the permanent staff of service personnel. At each of the main stations, General San Martin, General Belgrano (on the Weddell Sea), and Esperanza, a scientist who has undergone a special course at the Snow, Ice, and Permafrost Research Establishment in Greenland, will supervise glaciological activities.

Australia. This year's base-establishing and relief expedition in *Kista Dan* has had a very awkward season. Yet, all the expedition's objectives were achieved and the timetable kept. Last season's wintering party reached Melbourne on March 12.

The circumstances surrounding the establishment of Davis station on the coast of the Vestfold Hills area is now clearer. On January 5, having found Mawson still ice-locked by 40 miles of fast ice, Philip Law (ANARE leader) with Clemence piloting, made a reconnaissance by air to the area, nearly 400 miles away. An ice-free area similar to that intended as the site for the new station was observed on an uncharted piece of coast. Since Vestfold appeared wholly inaccessible, Law thought to establish the new station at this position. *Kista Dan* was navigated on a course seawards from the Mawson area; she was close to the coast immediately south of the West Iceshelf on January 9. When a second air reconnaissance was made, however, Law became convinced that the "newly-discovered" ice-free area observed on the 5th must, through a navigational error, in fact have been the Vestfold Hills. The region taken to have been the latter and inaccessible, was probably the Larsemann Hills, much farther south.

Nevertheless difficulties remained. Approach to the coast lay through shoal water between off-lying islands and hundreds of grounded icebergs. However, on January 11 *Kista Dan* crept shorewards towards Ellis Fjord with the *Beaver* aircraft in close support. Apart from the difficulties of getting the ship close in, the shore terrain—a desert of moraine boulders sliced by high ridges and gullies—was impracticable for the shore-vehicles, tractors, and DUKWs. Five sites were reconnoitred and rejected; the sixth was approved for lack of anything better. Lack of a freshwater supply in summer (when the extensive area seemed completely devoid of snow, ice, or water that was not brackish) was overcome by constructing an evaporation-still aboard *Kista Dan* and filling a number of drums with ice-blocks from the nearby bergs.

The party began unloading on January 12 and continued work for eighteen hours a day for four days. Stores came half a mile from ship to shore by DUKW, then up a rough track partly cleared of boulders to a pebbled terrace 80 feet above the sea, the camp site. Behind, on the summit of the ridge, the main scientific apparatus was installed in a position giving excellent exposure.

By the end of the 16th, sleeping hut, community hut, auroral observatory, the food stack, and most of the engine hut were built, and the radio masts rigged. In 1954 *Kista Dan* had met a 90 m.p.h. hurricane in this neighbourhood so that Law knew the remarkable fine spell could not be trusted; sure enough on the fifth day, the 17th, a 40 m.p.h. gale struck.

By the 20th, however, Davis was complete—all huts built; generator working; radio, electric-stove, lights, and heating in operation, and water distillation proceeding satisfactorily. *Kista Dan* left that day for her meeting with the Americans off the Windmill Islands on January 24. Davis at 68° 34·6′ S. 77° 58·6′ E was now operational under its staff of four, which in February was increased to five by a Norwegian meteorologist from the Windmill Island party.

On January 30 the expedition ship was back off Mawson and had penetrated to within forty miles through a litter of grounded icebergs when a blizzard came up. *Kista Dan* had to retreat north to open water through blinding snow and a wind which reached force 10 (round about 60 m.p.h.). Next day, while conditions remained much the same, the *Ob* suddenly loomed through the drift. She later radioed her regrets that the storm had prevented her visiting the Australian station. On February 2 *Kista Dan* pushed her way southwards for eight hours through pack before emerging into open water near Mawson harbour. Unloading from the ship began at Mawson on the 3rd and the relief party's job was done by the 14th. *Kista Dan* sailed from Mawson on February 17 leaving "an elaborate observatory of thirty huts" occupied by the staff for the coming year under K. B. Mather. There was a final call at Davis with more stores, and then the return to Australia via the French island of Kerguelen—a round trip of 11,500 miles in three months. *Kista Dan*'s longest Antarctic cruise so far.

Philip Law (ANARE) has now reported that the scientific installations at all three Australian Anarctic stations were operational by the end of March. Their scientific status is now as follows:

Macquarie Island. Four additional instruments have been installed this season: a cosmic-ray meson telescope; an all-sky auroral camera (developed in Australia); a Dobson spectrophotometer for studying ozone in the atmosphere, and equipment for recording the so-called "whistling" atmospherics. Modifications have been made to the ionospheric sounder already in operation. Meteorological, geomagnetic, and seismic observations are continuing as before.

Mawson. The observing programme has been extended through the installation of an ionospheric recorder, meteor-tracking equipment for upper-air wind determinations; all-sky camera and phototheodolites for measuring the auroral parallax, and a twelve-counter cosmic-ray neutron monitor for supplementing the data from the two large meson telescopes. A programme of glaciology (including ice-depth measurements) has been introduced. Equipment for recording rapid magnetic fluctuations was this season installed to extend the geomagnetic programme already under way. Meteorological and seismic observations also already in full operation are continuing. The Mawson staff has been expanded to twenty-four men this year (all but the cook, two diesel mechanics, and four pilots being scientific personnel).

Two *Beaver* aircraft are based at Mawson and in May inaugurated a regular "service" between ANARE's two continental stations—about 400 miles and four hours' flying time apart. A third Beaver is on order to join the flight for the 1957–8 season's flying, ferrying, and surveying programme. Announcing this the Australian Minister for External Affairs said that ANARE's use of aircraft in Antarctica had at least doubled the effectiveness of the Australians' work.

Davis. The programme here covers meteorology, geology, and observations with the all-sky camera.

Windmill Islands. The French-designed robot weather station was satisfactorily installed at this location by seven members of ANARE operating from the U.S. transport *Arneb* during her activities in the area establishing the American Vincennes Bay station. The installation automatically measures pressure, temperature, wind-speed and direction, and relative humidity, then transmits the data 12-hourly for Perth or Hobart (Tasmania) to pick up. It runs on batteries charged by a wind-generator.

Altogether Australia is to spend £A1 million on research in Antarctica during the IGY. The robot weather station alone cost £10,000.

Belgium. The leader-designate of the Belgian expedition in the coming Antarctic spring, Gaston de Gerlache, accompanied the past season's French relief party to Terre Adélie, as an observer. It is understood that the Belgian expedition has chartered the newly built Norwegian sealer of 600 tons, the M.V. *Polarhav*, for next season's base-establishing expedition to Breid Bay.

The Belgian Government has allocated the sum of 40 million Belgian francs for this expedition; it is expected that this will be augmented by grants from several scientific organisations.

Norway. On March 12 radio contact with Norway was first achieved after the departure of the expedition ship on January 20. It was reported that the weather had been reasonably favourable, enabling the building programme to be completed without much trouble. A mast 156 feet high (26 m.) had been put up for weather observations.

U.S.S.R. A survey by aerial photography of 15,000 sq. km. in the Mt Gauss to Bunger Oasis area was carried out during January 1956. Last autumn a further 15,000 sq. km. was air-surveyed between Mirny, Depot Bay (otherwise known as Farr Bay), Bunger Oasis, the Shackleton Iceshelf, and some of the coast to the east.

A tractor-train left Mirny on April 2, 1956, with a party of eleven men to set up the intermediate inland station of Pionerskaya. This was sited at 69° 44′ S, 93° 30′ E on May 4. On the sledging journey a traverse of snow density was carried out as well as magnetic observations measuring declination and horizontal and vertical components.

For about a fortnight during the winter of July and August (1956) temporary meteorological stations were operated along the 93° E meridian in the Mirny area, to study wind drainage and the region's microclimate.

At the end of October a glaciological traverse Mirny–Depot Bay–Shackleton Iceshelf, 250 km. altogether, was carried out by a dog-sledge party. Several profile sections of ice-cliffs were taken and ice samples collected. Later twenty-two reconnaissance flights were made to the Davis Sea area to observe ice conditions.

On February 24, 1956, a reconnaissance flight was made over the Geomagnetic Pole, but without landing. On March 3 a similar flight was made towards the Pole of Inaccessibility, reaching 78° S. (This so-called Pole, in Enderby Land, is approximately at 82° S, 50° E.)

These flights, together with other aerial reconnaissance, showed the Russians that the ice-cap rises steadily in the direction of the (geographic) Pole, here as in the Western Antarctic. The Geomagnetic Pole stands about 3500 m. above sea-level.

From the scientific work conducted from Mirny during the first season the following conclusions have been drawn: *Meteorology:* a predominance of meridional winds over the Indian Ocean in winter was inferred; *Glaciology:* the velocity of movement of ice-streams near Mirny showed a variation from a few inches to several feet per month. By means of ice-cap thickness soundings it was found that along the 90°E meridian 50 km. from the coast the glacier's bedrock lies 300–500 m. below sea-level; *Geophysics:* an increase in the vertical component westwards where a range of fixed icebergs lies, indicates that the sea bottom rises in relation to the bottom nearer the coast. This hypothesis was derived from measurements made at Mirny.

Pionerskaya station maintains meteorological, aerological, actinometric, and glaciological programmes but the scope is narrower than those at Mirny.

Oasis station's schedule gives it the status of a second-class scientific post only, but with some special studies added. For instance special attention is being given there to storm-winds for which additional instruments have been installed including a hurricane meter.

The inland stations. Komsomolskaya (now established), Vostok, and Sovetskaya are all scheduled to carry out observational programmes comparable with that of Mirny.

This past season. The *Ob* left Kaliningrad for Antarctica on November 7, reaching Mirny on December 11; the small freighter, the *Kooperatsia*, sailed from Russia on November 25 and reached Mirny January 10; *Lena* left on December 11. *Lena*, last to arrive, was prevented by the ice conditions from going to her previous unloading point. She moored against the ice-edge 200 km. westwards from this point, where the additional aircraft for the expedition were unloaded; these were badly needed for establishing the inland stations. On January 26 she moved to the coast immediately off Mirny where she tied up to a 15 m. ice-cliff. Shortly after, part of this cliff broke off while work was going on and two men were killed in the accident and four others injured (two of them seriously).

Pionerskaya (the one inland station established during the previous season) was relieved as early as November 17 by air. As soon as possible after the *Ob*'s arrival, a ground relief party set out for Pionerskaya by tractor-train. This arrived at the station on January 7, depoted fuel, and returned. The station was again relieved by air early in February; in the previous month and during early February no less than thirty sorties were made towards Pionerskaya for the purpose of depoting stores for the tractor trains that were to pass along this route for the interior later on.

The leader-designate of the Komsomolskaya intermediate station, Dr Vasily Pelavin, left Mirny with ten men and three tractor-trains on February 14. They had reached Pionerskaya by the 21st. The plan was to establish the Komsomolskaya station a further 500 km. beyond Pionerskaya, that is about 800–900 km. into the interior from Mirny. This plan was in fact achieved and the station erected in April.

A second expedition left Mirny for the interior on February 28. This was made up of five tractor-trains and its object was the establishing of the Inaccessibility Pole Station, Sovetskaya, 900 miles, approximately, from the coastal base. At the begiming of May it appeared that this party, though it had covered a considerable distance of this journey across a part of the continent never before seen by man from the ground, and only briefly glimpsed during aerial reconnaissance last year, would be wintering up at an intermediate point and that the station would not

now be put in until the coming Antarctic spring.

A third party left Mirny for the interior at the beginning of February. On the 7th an ambitious glaciological party was led out by Prof. Peter Shumsky, a forceful and brilliant scientist from the Soviet Arctic Institute, at the head of a team of fifteen. The plan was to make a triangular journey of 500 km. on the route Mirny–Vostok–Sovetskaya–Mirny. As they went the team would carry out a variety of glaciological measurements, including seismological sounding. It was not expected they would get beyond Komsomolskaya this season.

This is an account taken from the Soviet Bulletin in May based on a radio message received from Shumsky when several hundred miles along the route. "The party was moving over a string of mountains blanketed with ice more than 1600 yards thick and rising well over 3000 feet above the sea. The men had to rely on their instruments to gain any idea of the cross-section of the ice-buried terrain. They reported unceasing winds and blizzards which reduced visibility to a few yards, and frosts of up to 50°C. A slight concussion was enough to break a steel rope. The snow rushing at a terrific speed, became electrified and the ends of the steel wires strung by the seismologists would often be seen to glow at night because of electric discharges."

Later reports still, suggest that a Vostok I station was established, at the beginning of April or thereabouts, some 400 miles inland from Mirny and at a height of 10,000 feet in a mountainous area. This is about half-way from the intended position of Vostok.

The various wintering parties this year amount to 188 men, as against 92 last season. *Kooperatsia*, with last year's wintering party under Dr Somov, left Mirny in February and docked at Leningrad on April 5. *Ob* and *Lena* sailed from Antarctica in April.

Chile. A tanker, a transport, and two patrol-vessels were operating in the region of Graham Land from the end of October (1956) into May. On the relief voyage through the Drake Channel to the Capitan Prat (naval) station the ships had a rough time. The O'Higgins (military) station's relief party was air-ferried as far as Punta Arenas and there embarked in the transport *Rancagua*, which took them the rest of the way.

An offshoot of the O'Higgins station, to be called Luis Riso Patrón, is being established specifically for IGY scientific studies. In the season just past, thirty-eight scientists were carried by the relieving ships; they conducted observations in gravimetry, seismology, meteorology, auroral studies, glaciology, and marine biology. Nineteen of these scientists remained behind to man the new scientific station which is close to O'Higgins throughout 1957; the other scientists sailed home early in May, when this season's relief expedition returned to Chile.

Japan. The expedition entered the pack off Enderby Land early in January; *Weasels* were put on to the ice to reconnoitre and struggled as far as Ongul Island, off the eastern shore of Lutzow-Holm Bay within a week. Unloading was hampered by rising winds, heavy seas, and soft ice. A motor-sledge was almost lost when it broke through thin ice, and unloading was temporarily suspended. By February 17 all stores were ashore, and the ships sailed—nearly too late. The station, which was left with a wintering party of eleven, was named Showa.

The expedition ships were expected back in Toyko on April 26, after calling at Cape Town.

U.S.A. All the stations scheduled (six, including the joint U.S.-New Zealand station "Adare" at Cape Hallett) are expected to be scientifically operational by July 1. The United States has spent over £20 million on the preparations for IGY work in the Antarctic, it was revealed by Admiral Dufek (naval operations commander) as he passed through New Zealand on his way home at the end of the season. Next year's operation was expected to cost a further £5 million.

Marie Byrd station was put in by tractor-train—preceded by a ground reconnaissance party—in December. The first train returned early in January, and a second tractor-train with supplies set off shortly after. Byrd stands at 5000 feet.

After the loss of a man and the tractor-train he was driving last season on the route originally chosen, this year's reconnaissance party had the task of finding another more reliable route for the ground supply-trains. On November 8, Major Merle R. Dawson and his party left Little America V with two *Weasels*, a *Sno-cat*, two D8 tractors, and a crevasse-detector: 183 miles out a seven-mile-wide belt of deep crevasses was encountered where the Rockefeller Plateau meets the Ross Iceshelf. Using the crevasse-detector in conjunction with helicopter reconnaissance, a route through the danger zone was found; and, after thirteen days of blasting and bulldozing snow into the cracks, this was made safe for single-lane tractor traffic. The trail party got back to Little America on December 17—a considerable achievement behind them. On the way they passed the first loaded supply-train for the base; this made the 647-mile journey to Byrd in eighteen days. More stores were air-dropped on December 23 and 24, and the station was dedicated on Christmas Day. Further air-drops to Byrd took place in February after the arrival of the second tractor-train.

McMurdo Sound Airstrip. High temperatures rendered the Williams Air Facility unserviceable from the end of December until February 9; the slushy surface made it impossible for wheeled aircraft to land. This hold-up caused a "major upset in plans".

Four aircraft—three of them *Globemasters*, the other a naval *Neptune*—were either destroyed or severely damaged before flying was stopped. Four lives were lost in the accidents. Two helicopters were also lost and much ground transport damaged. During this period of considerable surface ablation a *Weasel* went through the ice with its driver; five men escaped.

Surface-hardening techniques were put into operation, and these enabled the strip to come into use earlier than would have otherwise been the case. A suitable site for an airstrip on land in this area was sought after these mishaps. Work is going forward, and it is expected that landings on the bay ice will be discontinued in the coming season.

Beardmore Strip. A small support and refuelling station for the aircraft flying to the South Pole station was established on October 28 at about 85° S., 165° W. This was just for the season's flying and the maintenance party of three left at the end of February.

This strip was named after Beardmore of the Beardmore Glacier, as it was originally intended to site it near the glacier's foot. As nowhere suitable could be found there, the strip was put east of the outlet of the Liv Glacier at the foot of the Duncan Mountains.

Wilkes station: In January the proposed site for the station in Vincennes Bay was screened from the base-establishing fleet by thirty-five miles of fast ice twenty feet thick. The fleet consisted of two transports escorted by the ice-breaker *Glacier* (in place of *Northwind*, which had had to withdraw for repairs after her battering off Cape Hallett).

Glacier went in ahead and succeeded in breaking out a bay in the ice for off-loading. This operation was not completed, however, without further damage to *Arneb* (transport). Landing-craft were also used to get the supplies ashore. Most of the building programme at Wilkes was completed within a fortnight; the schedule had been seven weeks, but extraordinarily fine weather made the speed-up possible; the delays already encountered made it desirable. The commissioning ceremony took place on February 16, and the ships left on the 17th. *Arneb*, crippled by a long gash in the hull beneath the waterline (the legacy from a Vincennes Bay hidden ice-floe), reached Sydney safely on the 28th.

Little America V. Difficulties in operating the Antarctic Weather Central are now understood to have been overcome. The Americans undertook to operate this for the benefit of all the expeditions. Meteorologists from several of the other countries with expeditions are also working at Little America. The difficulties centre on radio-communication failures; these are at least partly connected with the difficulty of achieving a satisfactory earth for electronic

equipment in a region entirely floored with snow and ice.

At last year's Antarctic conference in Paris, American communications experts were suggesting overcoming radio-telephonic difficulties by putting in a forward scatter station (such as they have linking the U.S. with Europe via the Arctic). This would hardly seem practicable in the time available.

Satellite Postponed

It was officially announced from Washington on May 20 that the launching of the first U.S. artificial satellite has been postponed until next spring.

The first launching was originally scheduled for September this year, and the date was later pushed back to November. The hold-up is said to be primarily due to the delays and difficulties of organising and installing the so-called "picket-fence" of twelve satellite tracking stations north and south along the American continent, for observing the satellite each time it circled the earth. Without these operating at optimum efficiency the whole elaborate and expensive project would have little value.

Though a first-stage rocket engine was rejected on static test in April, many of the other components of both launching vehicle and satellite instrumentation had passed their trials and were considered "ready" when the Washington announcement was made. The progress of some of these has already been recorded in DISCOVERY.

An important test in the series which marked the approach to readiness of the project took place in the early hours of the morning of May 1. It appears to have been a success.

This test proved two key components in the three-stage satellite-launching vehicle and its elaborate control mechanism; namely, the solid propellant (third-stage) rocket which will actually fire the satellite horizontally into orbit at 300 miles high, and the controls which operate the complicated separation procedure for this last stage. Since the (final) solid-propellant rocket is uncontrolled and at the same time only a tolerance of two degrees from the scheduled launching angle is permissible for the rocket, it is to be spun on its axis like a rifle bullet so as to stabilise its flight. For this to be effective the final-stage rocket must be "spun up" while still housed within the nose of its parent rocket.

In the test of May 1 only two rockets were used. The second-stage component which has been tested separately was dispensed with. A *Viking* rocket, the fourteenth *Viking* in the series made for U.S. Navy research by the Glenn Martin company and similar to the stage I rocket for *Vanguard*, raised the velocity of the vehicle to 3500 m.p.h. before burnout.

The vehicle coasted on from this point to a height of 120 miles; during this stage of the flight the direction tipped over from the nearly vertical to the nearly horizontal, which carried the rocket out over the Atlantic from the launching point, Cape Canaveral on the Florida coast. At 120 miles high the separation procedure of the spinning solid-propellant rocket was put into operation. The flight of this third-stage-type rocket was monitored electronically until burnout, when it dropped into the sea. This rocket motor was made by the Central Rocket Company. A similar contract has been placed with the Allegheny Ballistic Laboratory.

This test, since one of the velocity-increasing, height-raising rockets was missing, could not precisely simulate conditions at satellite-launching. Speed, height, and atmospheric values for the third stage will be different by several orders of magnitude.

H-Bomb Helps Seismology

At least one team of geophysicists made the most of the man-made eruption provided by the explosion of Britain's first H-bomb off Christmas Island to study the structure of the earth's crust. In April a team of American scientists led by a geophysicist from Imperial College, London, Dr R. G. Mason, set up a seismic station on Palmyra Island, an uninhabited island in the same group as Christmas Island but some 500 miles north-west.

It has several times been suggested by Prof. K. Bullen, F.R.S., of Sydney University, that as part of the IGY atom-bombs be exploded at various judiciously chosen positions at the Earth's surface (including the Antarctic) for the benefit of seismological studies. Dr Mason's party, from the Scripps Institute of Oceanography (California) and the U.S. Coast and Geodetic Survey, collected what data they could from the repercussions of a bomb exploded arbitrarily, as far as geophysical studies are concerned.

Palmyra's seismological station is only one of three stations to be established by this expedition. One of the main objects of the party is to make continuous observations during the whole eighteen months of the IGY of the electro-jet located some years ago in the upper atmosphere in the neighbourhood of the equator. It is thought that this little-understood phenomenon is associated with the Earth's magnetic equator, but how? Fanning Island, where the main centre of operations is to be situated for this study is the only land-surface in the world near the intersection of the magnetic and geographic equators, hence its choice. There will be sub-stations on Palmyra and also on Jarvis Island; the latter lies very nearly on the geographic equator. Particular attention will be given to the variations of the electro-jet with the continuous magnetic and ionospheric variations locally and the effect on all of these of solar flares and other causes of electromagnetic disturbance.

It is expected that the U.S.S. *Glacier* will be launching some rockets to help the study of the Earth's system of three electro-jet currents during her next Antarctic cruise. Three of these ring-currents have been located, one circling each pole and the other at the equator.

Polish Reconnaissance in Vietnam

Pursuing the plan to send a Polish IGY expedition to Northern Vietnam for work on seismology and meteorology, announced last May at a meeting in Warsaw (DISCOVERY, 1956, July, p. 289), reconnaissance party of four Polish scientists spent three months in the country last autumn. The full expedition is by now expected to be in position.

The programme will be carried out in co-operation with Vietnamese organised by the Hydrological-Meteorological Institute of the Republic (Prof. Nguyen-Xien) which is associated with the recently opened Hanoi University.

A chain of active met-stations in the interior of the country was visited by the Poles, and a brief expedition to the Tam-Dao mountain belt was included in the trip. Phu-Lien, once a well-equipped research station on the coast, which was distinguished between its inception in 1909 and the recent war for important typhoon observations, was selected as the site for seismological work. Here upper-air and also evaporation measurements will be made. Though much of the observatory was destroyed in the war, some of the installations are intact and can be put to use.

The principal geophysical station to be established by this year's Polish expedition, however, was planned for a site high in the mountains of the interior, Cha-Pa, where there used to be a tiny European settlement which ran a met-station. Cha-Pa has not been occupied for some time, and access to the site at 4000 feet, which lies through tropical rain forest, is not easy. The last part of last autumn's journey had to be carried out on foot.

The four Poles, accompanied by twenty Vietnamese scientists and technicians, set out for the location at the end of October. They found no suitable buildings for their work left standing. Though considerable building work proved necessary, preliminary surveying and magnetic observations in the neighbourhood of Cha-Pa were satisfactory. The reconnaissance party camped for nearly a month at Cha-Pa and carried out several field investigations in the locality.

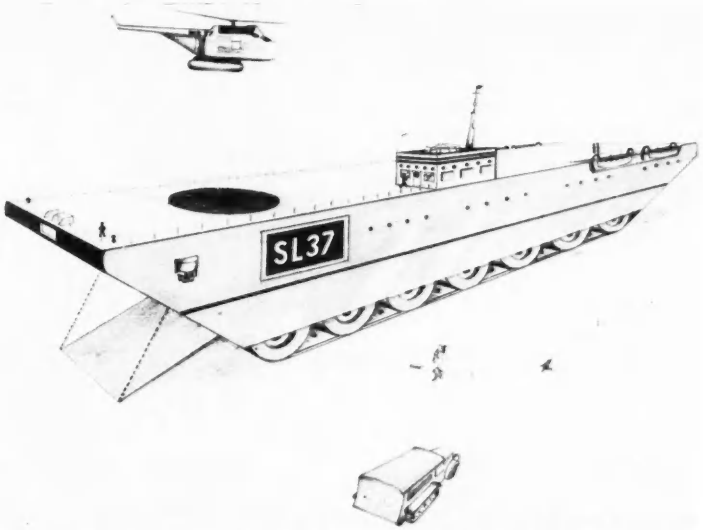
The members of the Polish reconnaissance party were: Prof. S. Z Rozycki, Director of the IGY Expeditions Subcommittee of the Polish Academy of Sciences; Prof. Roman Teisseyre, head of the seismology department of the Polish Geophysical Institute and leader-designate of this year's expedition; Dr K. Chomicz of the Polish Institute of Hydrology and Meteorology, and Dr P. Czerski.

LETTERS TO THE EDITOR

Giant Polar Tanks

Sir:

The present interest in Antarctic exploration makes it opportune to suggest an improvement in the method of crossing ice-fields with stores and equipment. The idea is to build a giant amphibious tank for polar research, say 150 ft. long by 50 ft. wide by 35 ft. high. It would really be a large barge built on caterpillar tracks. At the stern could be two propellers and a rudder. The appended drawing shows how it might appear.



The tank could be sailed to a suitable beach on the coast of Antarctica. There the engines would be disengaged from the propeller-shafts and geared to the track wheels, enabling the tank to crawl up the beach. It would be advisable to take off the rudder and propellers with the aid of a crane in order to avoid damaging them.

The tank would be so large that it would be able to cross crevasses and the smaller irregularities in the ice-field. It would be able to reverse as well as go forward. Since its speed would be about five miles per hour, it should be able to cover well over a hundred miles in one day.

Such giant tanks could revolutionise Antarctic exploration. A party of about forty surveyors, geophysicists, geologists and meteorologists would be able to travel with much heavy and bulky equipment, enabling them to make far more comprehensive observations than have been made hitherto. The laboratory facilities would be almost as good as at a stationary laboratory, and the standard of comfort comparable to that on a submarine. The speed of travel would be six times faster than by sledge. There would be more time for observation, since less time would be spent on merely keeping alive and moving around.

If minerals in commercial quantities were found in Antarctica, their exploitation would be helped by the use of these tanks. The ore could be transported across country from the mines to the beaches and transhipped into ocean-going vessels lying offshore. They would return with stores of all kinds. Thus the development of giant tanks for scientific research could lead to the exploitation and colonisation of Antarctica.

There are several criticisms of the idea which can be answered straight away. Would the tank be so heavy that it became stuck in the snow-field? The answer is that the tank need not be as heavy as a military tank of the same size, having neither gun, turret, nor protective armour. It need be no stronger than is required to withstand the stresses imposed on it, and could be built of aluminium alloy in order to save weight.

Large tanks are not intrinsically unsound from an engineering point of view. The reason why military tanks are small is that they must be light enough to pass over bridges and small enough to pass under them. If these restrictions were removed, it would be possible to build really large tanks. The giant tank should be seaworthy if designed properly.

It would be necessary to choose the landing-place with care. A sheltered beach free from rocks would be ideal. The ratio of weight to area of tracks would be small, so there would be little possibility of becoming stuck on the beach.

Perhaps several nations could be induced to contribute to the building of an International Geophysical Giant Tank. The co-operation of the Scandinavian countries would be particularly welcome, since it would be wise to test the tank thoroughly on the ice-fields of Greenland before sending it to Antarctica. If oil should be discovered there, the oil companies would benefit by the development of these tanks. They might be persuaded to contribute if they could be shown that the development of a scientific tank would make possible the building of commercial tanks for oil transportation.

I hope that this letter will evoke suggestions and criticisms from those interested.

DAVID HILL,
B.SC., A.R.I.C.S.

12 Tithebarn Street, Liverpool 2.

Congestion at Road Junctions

Sir:

In connexion with J. S. Courtney-Pratt's admirable suggestions put forward in your May issue, p. 212, may I point out that some County Surveyors have found a different but equally effective solution to the problem of the side road traffic entering and leaving the main road at a T-junction? This has been done by forming a wide but shallow mouth to the side road, as is shown in Fig. 1. No island is needed; the dotted white line guides the E–W main-road traffic; the side-road traffic can filter in when turning left and wait to turn right without blocking the road.

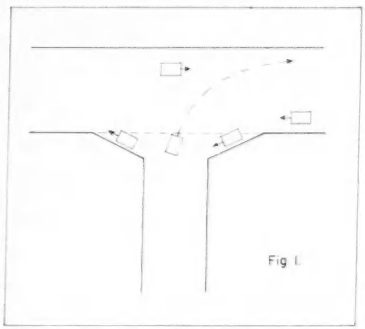


Fig. 1.

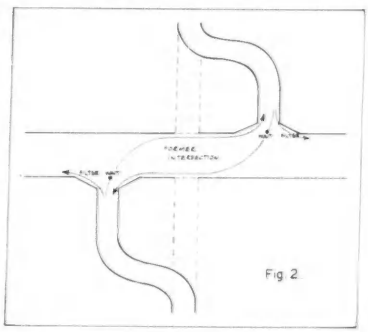


Fig. 2.

Main-road traffic wishing to turn left has an easy manœuvre to perform.

If this system is applied to uncontrolled cross-roads, it is very desirable to stagger the entry-points, as was done by Col. Bennett in Oxfordshire (Fig. 2). This has the great merit of reducing accidents as well as delays.

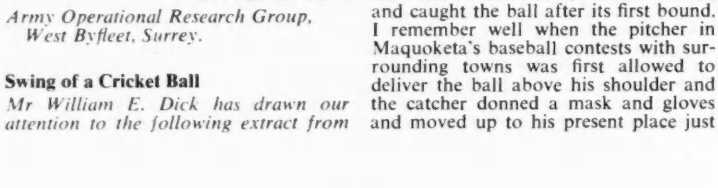
D. F. BAYLY-PIKE.

Army Operational Research Group, West Byfleet, Surrey.

Swing of a Cricket Ball

Mr William E. Dick has drawn our attention to the following extract from "Millikan" (London, Macdonald and Co., 1951):

"When as a child I first played in this game [baseball] in about 1876, the rules, like those of cricket at that time, required the pitcher to deliver the ball from below his knee. The catcher stood far back of the batter, wore no mask, and caught the ball after its first bound. I remember well when the pitcher in Maquoketa's baseball contests with surrounding towns was first allowed to deliver the ball above his shoulder and the catcher donned a mask and gloves and moved up to his present place just behind the batter. It was this change that brought in the curved ball, a phenomenon which my father, himself a college graduate, stoutly maintained was an impossibility, an optical illusion of some sort, until we boys set up three poles in a line in our back yard and my cousin repeatedly pitched a curved ball so that it visibly began and ended its flight on the west side of the two end poles but passed the middle pole on its east side. Father was then scientist enough to withdraw his opposition to the curved ball, though its theory, so far as we knew, had not yet been worked out."



Education Through Television

Two important new educational developments are being sponsored by the Independent Television Authority. First is the five-day-a-week television broadcast to schools from 2.45 p.m. to 3.15 p.m. which began on May 13, a programme arranged by Associated-Rediffusion Ltd. Second was an announcement in *The Times* of May 15 that Granada Television is contemplating the endowment, in a northern university, of a Chair or Lectureship to promote the academic study of the possibilities and uses of television as a medium of communication, of entertainment, and of arts. It is further considering the establishment of both a graduate research scholarship and a lecture course. The universities are, of course, to be consulted in connexion with the whole project.

It would seem self-evident that the projected Chair or Lectureship would be likely to be concerned largely with the sociological aspects of television. The creation of such a Chair is to be applauded, but the filling of the Chair might prove a delicate task. It is of course only to be expected that the acceptance of the Chair by any university automatically implies complete freedom of choice of appointment by that university. Hence the taking of such a step by Granada is a happy proof of the complete confidence that Granada has in the immense cultural power lying latent in the hands of ITA. Who knows but that this may only be the beginning of a fruitful co-operation between the universities and the ITA programme builders.

Thursday, May 16 witnessed in England the first *science* broadcast to schools in the new Associated-Rediffusion school programmes. Appropriately enough the theme selected was the International Geophysical Year and it was directed and scripted by John Frankau, with the aid of a scientific adviser. The whole structure of the broadcast was well conceived, consisting as it did of an admirably illustrated discussion between two principals and a chairman. The central figures were Dr D. C. Martin, the Assistant Secretary to the Royal Society, and Dr A. Moore of the IGY office of the Royal Society. An able introduction was presented by the chairman, Redvers Kyle.

The aim of the broadcast, which was so well planned as to appeal to a considerable age range, was to explain in an introductory way the meaning, scope, and justification for the activities described as the Geophysical Year Programme. It was stimulating and exciting, and succeeded admirably in its object. There was a well-knit interplay between film shots, animated diagrams, and live discussion. In particular those sequences dealing with the conjectured *physical* evolution of the earth must surely have been of real excitement to any boy or girl. (The gloss over *biological* evolution was a rather sorry, scrappy, and jerky performance, the only weak spot in the production.) The broadcast concentrated mainly on the upper atmosphere, and we were told that the interior of the earth and the ocean depths were to be subjects for later broadcasts.

This was teaching at its very best, using an excellent variety of short film shots, a fine restrained use of animated diagrams (one can overdo this only too easily), and, best of all, the personal touch, with object and analogy in the very hand of the lecturer. A surprising amount was put across for one half-hour. Indeed perhaps the pace was too fast since there were occasional slips in the production. More than once, in switching through from film soundtrack to live broadcaster, the first word or two of the live broadcaster was lost. This was a pity and can easily be remedied in the future broadcasts.

With commendable taste there was no hint of advertising either before or after the broadcast. The Independent Television is to be congratulated on an excellent beginning. It has set itself a standard such that it will find it hard to better its own example. S. TOLANSKY.

Films in Industry

A conference on the Use of Film in Industry convened by the British Productivity Council took place during the Factory Exhibition at Earl's Court. During the first session L. H. Hornsby, C.B.E., of the Ministry of Labour and National Service, gave a short introductory talk on the useful rôle industrial films might be able to play in management-labour relations in factories, although he underlined the difficulties of the task by showing "The Film that Never Was", a brave attempt made by World Wide Pictures Ltd. to provoke discussion on the subject. It succeedec in provoking some discussion, and is likely to continue doing so.

Mr D. A. Gladwell of Richard Thomas and Baldwin explained the use made by this large steel combine, for instance in telling the history of the firm in "Going Together", made by Technical and Scientific Films Ltd. and in keeping the staff continuously informed about the firm's affairs by the filmed house magazine "Ingot Pictorial". A safety-first picture, "The Man Who Stops Accidents", also produced by Technical and Scientific Films, deals with a difficult subject, too, and was not always acceptable to the audience, perhaps because it sometimes emphasises the obvious.

Edgar Anstey, speaking on the part played by films in the nationalised industries, mentioned that the British Transport Commission uses films to a considerable extent for external publicity such as stimulating travel, for instruction within its vital staff training programme, and for internal staff information, for example, by its filmed house

magazine. He showed "Do You Remember?" as a sample of the first kind of film, an effort to ease the burden of the Lost Property Office. This speaker emphasised the necessity of bearing in mind the type of audience to be addressed from the first planning of the picture, and, consequently, the importance of expertly planned distribution through the appropriate channels.

Donald Alexander, talking of his work at the National Coal Board, also made a distinction between external and internal dissemination of publicity and instruction. The film "Shaft Survey" shows the introduction of work study into one of the mines. This film, too, makes the audience realise that genuine co-operation between management and staff is imperative for efficient production, but it ought to be supplemented by another showing how the waste of time and labour, sometimes of materials as well, detected by method study is subsequently eliminated, and how the resulting economies are distributed among the staff, the management, and the public which owns the mines.

Paul Fletcher gave a polished talk on the use made of films by the British Productivity Council illustrated by "Work Study, Its Application to Team Work" in a hot-dip galvanising plant, and by "The Unforgiving Minute", made by Anvil Films about work measurement.

The unmistakably technical audience was quite willing to be impressed and supported the enterprise of the British Productivity Council with some constructive criticism.

Industrial Screen is a new periodical published by Robin Publications Ltd. of 156 Grand Buildings, Trafalgar Square, London, W.C.2, and edited by Robinson P. Rigg. Received with all the best wishes by the trade, well printed on art paper which enables reasonably good half-tone illustrations to be shown, with a cover "still" by Walter Nurnberg, it puts over the industry's point of view in a number of well written contributions. It should make an impact on such executives in general industry as may care to read it and are likely to become converts to the cause of industrial films.

An introduction professes faith in the mission of the industrial film in our time. A kind of refined gossip column by Toni Rose puts the reader into the picture about current events of interest to members of the trade. The thorny problem of what a production may cost is ably tackled by Gerald Cookson. Derek Hill discusses the merits and advantages of cartoon commercials. Some of the channels open to the distribution of industrial films are disclosed by A. Vesselo. Ian B. Brigson gives his views on some of the wiser customers. Gordon Davis reviews films on automation and atomic energy, and appends a list of a dozen films and the sources from which they can be obtained. An index of twenty-six advertisers is impressive.

If this issue catches on with those to whom it is primarily addressed, a service can be rendered to industrial film producers and distributors alike, to industry in general, and to the country at large.

A. LASSALLY.

The Television Society

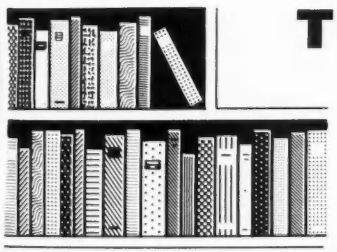
Speaking at the 28th Annual General Meeting of the Television Society, held at 164 Shaftesbury Avenue, London, W.C.2, on Friday May 10, 1957, the Chairman of Council, Mr D. C. Birkinshaw, said that the Society's transmitter was now in regular operation at Norwood Technical College. Transmissions were taking place on Mondays, Wednesdays, and Fridays from 7 to 9 p.m. with Test Card C and a tone.

In addition to offering a service to the radio industry for testing Band IV reception, the Society hoped that the transmission would serve as a means of training students at the College, and that in future it might be possible to televise some of the lectures given there.

Science in Colour

A complete course in high school physics has been filmed in sound and colour in the United States. The film was financed by a $500,000 grant from the Ford Foundation for the Advancement of Education to help schools that lack science teachers. A number of high schools in the State of Wisconsin will offer the course next autumn term.

THE BOOKSHELF



Rocket

By Air Chief Marshal Sir Philip Joubert de la Ferté (*London, Hutchinson, 1957, 190 pp., 18s.*)

What would have been the result if the first V2 had fallen not on September 8, 1944, but six months earlier, on March 8? With the whole French coast to launch them from, Hitler might have been able to disrupt the Allied invasion plans, and then what would have happened? There can be little doubt that the Allies would have won in the end, because they had overwhelming industrial, technical, and manpower superiority. But in the process, which would have been long drawn-out, they would almost certainly have used the atomic bomb, and what would have been the historic repercussions of that?

The V1 and the V2 were very considerable engineering achievements for which their creators deserve respect. But the use of these weapons in war brought to light a number of new problems, many of them not foreseen by their designers, and which must be solved by designers and strategists before such weapons can take their place as war winners. Two such outstanding problems are those of reliability and priority. The proportion of duds among the V2's was directly related to the length of the period which elapsed between manufacture and firing, and for those for which this period was longest the proportion of duds was high enough to make them an ineffective weapon of war. It is at least questionable whether this problem could have been solved in time to bring the V2 into service on the scale needed to make it effective six months earlier than it was in fact used, even had Peenemünde not been bombed, and even had General von Dornberger's team been given all the support that it might have had from the start, and had no competing projects been allowed in the field to draw off talent and supplies. The second problem, that of priority, is illustrated by the statement which has been attributed to Speer, that each V2 produced cost the Germans two fighter aircraft which could have been built instead. The squadrons thus lost to Germany might have staved off defeat for a while, and so brought the atomic bomb again into the picture.

Such speculations, which can never be finally resolved, are provoked by Sir Philip Joubert's book "Rocket". He tells exciting stories of the intelligence investigations into German rocket engineering, and of the costly RAF attacks on Peenemünde and the sites in Northern France, hanging them on the pegs provided by a brief history of rocketry and of the German V1 and V2 weapons. The book is rounded off with an exposition of Sir Philip's views on future military and political strategy. Sir Philip is at his best when he is talking about things which come nearest to his own experience, and the best parts of the book are his discussions of the development of aerial photographic reconnaissance and his detailed story of the bombing raid on Peenemünde, which brings the thrill and horror of such an operation to life. Though the book is not wholly satisfactory, it will

be valued by students of the influence of technical development on the progress of warfare. S. M.

Proceedings of the Third International Conference on Electron Microscopy

General Editor, R. Ross (*London, Royal Microscopical Society, 1954, 705 pp., 189 plates, £4 10s.*)

Thirty years before the conference reported in these proceedings, Louis de Broglie predicted that the electron should exhibit wave-like properties. Three years later this was confirmed experimentally by Davisson and Germer for slow electrons and by Sir George Thomson for fast electrons, by the demonstration of the diffraction of an electron beam by a crystal lattice in a manner analogous to the diffraction of light by an optical grating. These discoveries, together with Busch's treatment of the focusing of an electron beam by a magnetic field, paved the way for the development of the electron microscope. A common interest in the design and use of this instrument brought together scientists from all parts of the world to participate in the conference reported in this well-produced volume.

The growth of electron microscopy has benefited greatly from the interchange of views and ideas between instrument-designers and users. There can be few international gatherings which can claim among their number experts in such diverse fields as wave mechanics, electron optics, metallurgy, chemistry, cytology, virology, bacteriology, fibrillar structure, to name but a few of the subjects covered in the proceedings. Besides maintaining the subject itself in good health, this meeting together of scientists from so many different disciplines combats the tendency towards the fragmentation of science so prevalent today as a result of the increasing volume and complexity of our knowledge of nature.

In reviewing the present (1954) status of the subject, the late Prof. von Borries estimated that there were about 1300 electron microscopes in use throughout the world. Today there must be close upon 2000, and one can regretfully visualise a situation soon arising in which the instrument will no longer exert its unifying influence but will be accepted as a standard laboratory instrument like the optical microscope.

One of the highlights of the conference was undoubtedly the convincing demonstration for the first time of electron micrographs with a useful magnification of one million diameters making visible individual particles separated by less than 10^{-7} cm., a distance equal to only a few atomic diameters. The extraordinarily rapid technical progress that has made this achievement possible has left the user of the instrument somewhat breathless. Much emphasis was laid in the papers describing work carried out with the electron microscope on the urgent need to develop specimen preparation methods which permit the full exploitation of the high resolving power provided by the instrument-designers.

On the biological side, some success in this direction has been achieved by the development of more refined methods of cutting ultra-thin sections. Tissue sections below 2×10^{-6} cm. in thickness may now be cut as a routine, and they permit the observation of very fine periodic structures in muscle. It is also possible to study in this way diseased tissue with the eventual aim of understanding how viruses multiply, grow, and destroy the cells. The inner structure of viruses and bacteria revealed in thin sections will undoubtedly increase our understanding of their functioning.

In metallurgy, the electron microscope is extending our knowledge of the fundamental mechanism of deformation processes in metals. Very small slip steps, often less than 10^{-6} cm. in height, reveal the essential inhomogeneity of the deformation which is explicable in terms of the movement of dislocations through the metal. Our understanding of the hardening of alloys is advancing rapidly by electron microscopic studies of the extremely small precipitated particles formed during heat treatment.

The topics mentioned give some indication of the breadth of the subject matter covered in this volume of 158 papers. Working in the field of electron microscopy, one feels with Newton that we are as yet only picking up pebbles on the beach. The world of microstructure yet to be explored is certainly greater even than that revealed in three hundred years of optical microscopy.

J. W. MENTER.

Escape to Adventure

By Noel Monkman (*Sydney and London, Angus and Robertson, 1956, 182 pp., 21s.*)

It has been said, with perhaps much justification, that it is not necessary to be mad to make films, but that it certainly helps. In Europe, America, and other film-production centres, an excess of madness is almost invariably curbed by a drying-up of financial resources, and the film producer, sadder, wiser, but otherwise unhurt, must either make different films or turn to other means of earning a livelihood.

As Noel Monkman has proved, a film-maker in Australia must, in addition to ample finance and his charming streak of madness, have at least a minimum of nine lives—or eighteen if his wife's are included—such are the dangers of making films in the bush, on the coral-reefs, or catching crocodiles. Dangers might well be dismissed as mere occupational hazards of Hollywood travelogues, but if they are a part of making scientific biological films such as Monkman's, then they enhance his work as one after the other of his nine lives are risked to get just that essential shot into the can. Many will remember the famous American film, "The Sea Around Us", but few will have realised that more than half the scenes, including the complete cinemicrographic sequence and many underwater shots, came from Monkman's cameras.

Great artistic works usually leave the beholder unaware of the creative effort behind them, and Monkman's films certainly do so. However, his book reveals his patience, his immense skill, and his astonishing ingenuity, so that we appreciate his films even more. One example must here suffice. Because of the very real difficulties of technique, which the reviewer knows only too well from his own experience, few have attempted cinematography through the microscope, and then only in the calm of their laboratory with all possible facilities provided. To carry out cinemicrography in colour on the beach of a coral-reef, where there is nothing at hand except the sun to act as a blinding source of illumination, is a unique achievement. It will rank as high in the annals of scientific cinematography as H. G. Ponting's unsurpassed feat of single-handedly exposing and developing a complete motion picture in the Antarctic during R. F. Scott's expedition in 1911. If Ponting's film is today an undying inspiration to successive generations of polar explorers, one may well predict that Monkman's films of the Barrier Reef will be so for biological film-makers in the tropics. It is a pity, therefore, that his book lacks a complete list of his own films; perhaps this can be added as an appendix in a second edition.

But "Escape to Adventure" is far more than the memoirs of a film-maker. It is a first-class popular biological book about many of the little-known Australian species, ranging from insects, fish and other underwater animals, to crocodiles and birds. Monkman has the happy gift of bringing the "wild places and their peoples" to life, whether it is through his film-camera or through his book. The description of the spider *Nephila*, how she captured a small green bird in her web, and how she was wooed by a diminutive male, is as magnificent a nature study as his film of the same subject is a splendid example of the art of the motion picture. Those unfamiliar with Australia would have been happy to see a map, and an index to the animals described might also have been included.

Monkman's achievements as a microscopist are also outstanding. All the beautiful illustrations in this book, whether colour or black and white, are, of course, the author's; but there must be few who have illustrated their book with their own photomicrograph of the diatom *Amphipleura pellucida*, clearly showing its dotted structure. There can also be few "diatomaniacs" who have risked life and limb by descending the vertical walls of an extinct volcano in order to collect from the lake in the crater specimens for study and for filming.

The reviewer remembers urging the author several years ago to publish his

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exciting adventures and his biological observation. He now repeats what he then said in private: Monkman's work is so outstanding that it deserves the widest possible audience.

A. R. MICHAELIS.

Third International Congress of High-Speed Photography

Edited by R. B. Collins (*London, Butterworths Scientific Publications, 1957, 417 pp., 70s.*)

It is very gratifying to receive the Proceedings of an international congress only six months after the meeting was held. The Department of Scientific and Industrial Research, which carried the burden of organising the Congress, is to be highly praised for adopting from the start the policy of having all the papers preprinted and made available to the Congress members before the opening. This not only made it possible to have the Proceedings published with the shortest possible delay, but also to restrict the speaking time allotted to each author and hence to leave ample time for discussion. This is reflected in the Proceedings, and it is even more apparent from the written version of the discussions how specific and pertinent were the questions raised by the various contributors, who had obviously studied the papers carefully in advance. It is to be hoped that the organisers of future conferences will follow the example thus set by the Third Congress.

Another highlight of the Proceedings is the high standard of the published papers, due to the fact that all papers submitted for presentation at the conference were carefully examined by the editorial panel, and that a good many of them were actually rejected. Thus, with very few exceptions, only new work, not described in previous publications, was reported at the Congress and, therefore, published in the Proceedings.

When glancing through the book, one immediately senses the hard work performed by the editor, R. B. Collins, and his colleagues, in keeping the right sort of balance between individual papers and thus achieving a highly commendable presentation of the subject-matter. The numerous illustrations are outstanding, and the photographic reproductions of a particularly good quality, owing to the excellent glossy paper used. The authors themselves are to be thanked for the many references given at the end of their papers, a large proportion of which refer to papers published in the Proceedings of the Second Congress,* which shows the measure of continuity that was achieved in this series of meetings. In fact, for many subjects, the two volumes are essential complements of one another and should be studied concurrently.

The work reported in the papers clearly shows a serious search towards increased performances of instruments using known techniques. A few years ago there was still a tendency to design new high-speed cameras for the sole purpose of breaking records in frame rates, without much regard for the quality of the recorded pictures. Now that high-speed cameras are finding more and more applications in the various scientific and technical fields, the need for a proper balance between space and time resolutions, already pointed out several times by Prof. H. Schardin, is fully recognised, and serious consideration is given to this problem in many of the papers. The concept of space-time quantity of information, the subject of the reviewer's opening paper, will no doubt become the guiding light of future designs.

The subjects covered include flash-light sources, image-splitting and image-sampling techniques, inertialess shutters, application to biology, medicine, machine analysis, ballistics and explosives, instruments aids, photographic materials, x-rays, film evaluation, schlieren and interferometric techniques, rotating mirror cameras, medium repetition rate cameras, application to aerodynamics and hydrodynamics. Among the many new instruments and techniques described, let us just mention at random new developments for increasing the efficiency of image-converter tubes, the use of television tubes as high-speed shutters, electronic circuits for the production of accurately spaced flash sequences, new portable, rotating-prism, high-speed cameras, magnetically suspended high-speed rotors, new rotating-beam cameras, cathode-ray tube microscopic cine-cameras, and an entirely new method of image-sampling using a mosaic-type cathode-ray tube. This very incomplete list is sufficient to give a fair idea of the wealth of material to be found by both designers and users in the Proceedings of the Third Congress of High-Speed Photography.

P. NASLIN.

Dante and the Early Astronomers

By M. A. Orr (Mrs John Evershed). New and revised edition, with an Introduction by Barbara Reynolds (*London, Allan Wingate, 1956, 359 pp., 30s.*)

Conceived by a person who was both Dantist and astronomer, written in an observatory on a mountain top in India, this book should have become famous as the most lucid aid to modern scholars in its field. It did not. The first publication seems to have misfired and has lain quite unknown to all but a handful of historians of astronomy. Now it has a second chance, and though slightly dated by forty-three years of progress in our understanding of ancient astronomy, it is still a most important source for all Dantists, Chaucerian scholars, and medievalists in general. It is also to be highly recommended to any non-mathematical reader who wishes to gain an understanding of ancient and medieval astronomy. It must not be forgotten that even in the days of universal learning, astronomy was a highly technical, highly mathematical pursuit. To represent Ptolemaic astronomy by stylised pictures of concentric spheres, circles, and epicycles, is to do it grave injustice and miss the point entirely. Thanks to the author and the ministrations of Barbara Reynolds, there is little excuse now for such perverse simplifications. The new edition has been given a small additional bibliography to bring it up to date. There are also several footnotes in commentary; particularly the reader is to be warned that the discussion of the date of Dante's entry into the Inferno—whether it corresponds to 1300 or 1301 (pp. 275–88)—can now almost certainly be laid to a simple confusion between the civil and astronomical styles of dating (p. 284, n. 2). Let us now hope that the stimulus of this republication will induce more people to take an interest in the scientific background which was so important an influence on medieval literature.

DEREK J. PRICE.

Laboratory Glassblowing

By L. M. Parr and C. A. Hendley (*London, George Newnes Ltd, 1956, 160 pp., 21s.*)

Laboratory Glass-Working for Scientists

By A. J. B. Robertson, D. J. Fabian, A. J. Crocker, and J. Dewing (*London, Butterworths Scientific Publications, 1957, 184 pp., 22s. 6d.*)

The early scientific worthies made most of their own apparatus with considerable benefit to the techniques involved. In a modern organised laboratory, however, shortage in research staff generally makes it inappropriate for researchers to spend time in making apparatus, and many will deplore the passing of what has been called the string-and-sealing-wax apprenticeship of young scientists. Plainly, particular circumstances give an optimum somewhere between these extremes, and certainly a knowledge of glassblowing will pay double dividends, for apart from the ability to make apparatus, the knowledge acquired is good insurance against the abuse of this versatile material through ignorance of its limitations.

No book can teach the skill, but only the know-how of glassblowing. This is the authors' declared aim in both these books: to give any reasonably dexterous person sufficient instruction to enable him to repair or prepare glass apparatus himself. In "Laboratory Glassblowing" the authors' presentation is on the basis that a recruit has already been won: they start with a description of the simple tools required, pause to enumerate the various glasses of interest, and accomplish their main task by describing the techniques, which are clearly illustrated. This presentation is logical from a teacher's point of view, but is not likely to enthuse those who do not know the fascination of this work, nor

* Actes du 2ème Congrès International de Photographie et Cinématographie ultra-rapides, DUNOD, 1956, Paris [DISCOVERY, 1956, vol. 17, p. 252].

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Proceedings of a Symposium held at the National Physical Laboratory in September 1956

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LONGMANS

that a useful degree of skill can be acquired literally in an hour or two. Glassblowing is much more a question of manipulation than of blowing, and it is manual dexterity and recognition of temperatures and temperature variations which count most. They can soon be learnt by experience, but in successful glassblowing an essential requirement is an orderly scheduling of the various operations, for it is usually fatal to interrupt operations because of the need to anneal the glass before allowing it to cool. This is where this book performs such a useful function.

The chapter dealing with the properties of glass could have been better presented. The authors attempt to explain the situation which exists because of a change in the convention for defining the softening characteristics of glasses, but they only add to the confusion. The useful comparison of the properties of the glasses in common use is similarly marred by indiscriminate use of the old and new conventions. The authors make the mistake of assuming that a trade-mark is sufficient indication of the composition and properties of a glass. "Pyrex", for example, is a trade-mark which is used by the manufacturers to cover glasses of several compositions, of which the chemical-resistant glass generally used in glassblowing is only one.

The book would have been improved by a short bibliography.

The authors of "Laboratory Glass-Working for Scientists" make a more academic approach to the subject. A short historical introduction is followed by a chapter on the nature and properties of glasses of interest. Descriptions of the tools and various arts and practices lead on to the main purpose of the book, which is to show that the scientist need not be daunted even by the more complex glass assemblies, nor by glass-to-metal seals. Indeed a feature of this book is the contention that by the use of clamps and a hand torch or blowlamp one can get by without any manipulative skill—particularly if low-expansion glasses are used. It would no doubt be misleading to suggest that any all-embracing new technique is presented, but the book should appeal particularly to those who are not prepared to teach themselves a new skill and yet wish to be able to cope with a glass-working problem when it arises. The many references increase its usefulness and it well merits a place on any laboratory bookshelf.

The authors of both books seem to take an amateur's pride in the inelegance of apparatus so long as it works! However the professional knows that neatness is also indicative of an economy of effort.

S. M. COX.

Journal of Insect Physiology

(To be published quarterly by Pergamon Press, in London, New York, and Paris)

In recent decades there has been a steady increase in the number of scientists and output of scientific papers; but there has not been a commensurate increase in scientific journals in the field of biology. As a result, delays in publication are handicapping progress in many fields. Many of us, then, will welcome this new periodical, the quality of which is attested by the papers in its first number, as well as the international representation and renown of its editorial board.

Prof. Wigglesworth, in a foreword, declares that the journal will emphasise the comparative nature of insect physiology, rather than keep rigidly in the entomological field. For any biologist there are, indeed, several advantages in working with insects. They are cheap and expendable laboratory material and their surgical manipulation is not likely to offend humanitarian principles, nor does it require a licence. True, they are rather small; but that is a challenge to ingenuity.

The style and character of this journal recalls that of the *Journal of Experimental Biology*; and I casually glanced through the first and last bound volumes available on a convenient shelf. Vol. 2, in 1925, contained one paper out of 28 on insect physiology; vol. 32, in 1955, had 16 on physiology of insects (plus six on other arthropods) out of 54. These figures tell their own story.

J. R. BUSVINE.

The Living Rocks

Preface by André Maurois, commentary by Geoffrey Grigson, photographs by Stévan Célébonovic (*London, Phoenix House, 1957, pp. 94, 64 photographs, 25s.*)

This book, the first in the series "Art and Nature", is the work of Stévan Célébonovic, with facilities granted by the Muséum d'Histoire Naturelle de Genève, the Muséum National d'Histoire Naturelle de Paris, the British Museum (Natural History), and the Geological Survey and Museum in London.

The first twenty-four plates show various inorganic mineral forms. Of all the inorganic crystalline forms, why have these twenty-four been selected? The answer is probably that they are among the most evocative for the abstract artist and the sculptor. This is no exhaustive scientific catalogue, but to contemplate at leisure and in peace the architecture of anatase and manganite, the sculptural shapes of axinite or stibnite or serpentine, or the abstract patterns of fluorite and descloisite appropriately magnified, is to respond with a strange sense of familiarity in the depths of one's being. The remarkable series of forty plates of organic fossil forms will carry this feeling much farther and to a wider circle. Starting with the Cambrian period, we follow examples chronologically through the ages, helped by a table of geological time. We are impressed not only by the variety of the forms but by the artistry and range of the photographer.

What is to be gained from possessing a book of this kind? It is food for the emotions certainly, but feelings are shortlived; if it increases understanding of the laws and the design existing in the natural world, then the emotional impact becomes more permanent. André Maurois expresses something valuable in his preface when he says, "It seems to me more logical to see such lines and forms as having been directly and spontaneously generated by an environment. For example, parallel ripples are left on the sand by waves breaking on the shore. The purely automatic, but rhythmical and continuously repeated, movement of the sea is responsible for these enchanting curves. . . . In the Stone Age primitive man strove to reproduce such effects by his own artistry, but Nature had already achieved them, without reflection, through the combined workings of time and motion. . . ." What is true of inorganic matter is no less true of living organisms. They too are moulded by their environment. . . . In some species . . . the ornamentations are so elaborate and appear so purely decorative that it is hard to understand how Nature came to create them. How can one account for shell formations comparable with the jewels of a royal crown? Why those intricate patterns of small raised dots? One cannot begin to fathom Nature's mysterious ways; one can only admire these masterpieces as one admires the peacock's feathers or the glories of the sunset."

Such an attitude as this cannot fail to stimulate. Abstract art would do better to reach out in this direction instead of being content, as it so often is, with the waste products of a diseased imagination.

The book will of course also appeal to biologists and geologists. Geoffrey Grigson surveys the material with the eye of an art critic and the interests of a naturalist and a collector. His writing sparkles with the many-sided knowledge that listeners to his broadcasts have learnt to enjoy. The mathematician who follows in the tradition of d'Arcy Thompson can here obtain material for the more precise discovery of material laws, for the illustrations can be profitably studied from the standpoint of "growth and form".

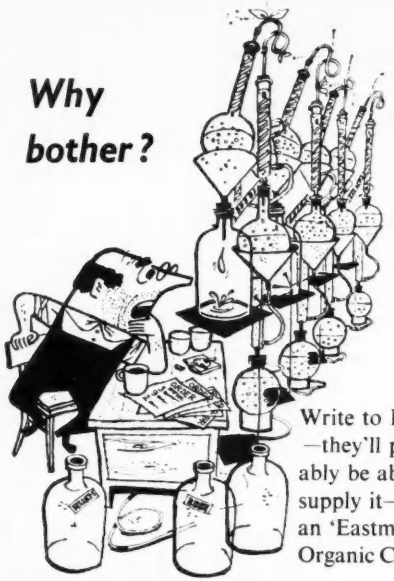
The translations by Joyce Emerson and Stanley A. Pocock are well done. If, as stated on the wrapper, "future volumes will carry the survey of natural and man-made materials, the inorganic and the living, from later times to the present", many will await impatiently for their appearance.

IRENE NICHOLSON.

Brief Notes

The work of WHO during 1956 is reviewed in the Annual Report of the Director-General published in March 1957 at 10*s*.

The Year Book for 1957 of the International Council of Scientific Unions has been issued from 29 Tavistock Square, London, W.C.1.



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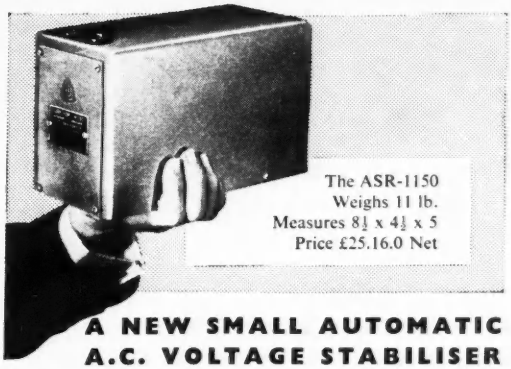

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Under (*a*)—1 post. Duties: to take charge of two experimental kitchens—candidates must have a sound knowledge of cooking, nutrition, and food chemistry. Organising and lecturing ability and experience of large-scale catering necessary.

Under (*b*)—5 posts. Two are at the Road Research Laboratory, Harmondsworth—one for work in connection with the civil engineering services of the Laboratory and the other for editing work and the preparation of bibliographies, in collaboration with the senior Scientific staff of the Laboratory, on matters of road-making materials and traffic and road safety; one at the Mechanical Engineering Research Laboratory at East Kilbride, near Glasgow; one at the Hydraulics Research Station, Wallingford, Berks, to take charge of the experimental work on problems connected with open-channel flow; one in London in the Technical Information Unit for which a reading knowledge of German and experience in a technical records section is desirable.

The 15 posts for (*c*) are classified under Applied Mathematics, Physics, Aeronautical and Mechanical Engineering, Electrical Engineering for work on guided weapons, electronics, aircraft equipment, etc. Some posts require knowledge of chemical engineering, applied physiology (clothing), and metal corrosion. Posts requiring experience of technical information work for which candidates may apply irrespective of scientific background may also be included.

Fuller information about the scope of the work is given in the memorandum.

Salary (London) minimum £1285 (women £1191). Men's scale maximum £1530. Exceptionally, starting pay above minimum. Somewhat lower outside London. Women's scale is being raised to reach equality with men's by 1961.

Application forms and memorandum from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S4713/57/15. Applications to be returned by July 31, 1957.

SENIOR ASSISTANTS (SCIENTIFIC). The Civil Service Commissioners invite applications for pensionable posts: (*a*) ADMIRALTY, 20; (*b*) ROYAL MINT, 1; (*c*) DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, 5; (*d*) WAR OFFICE, 5 (men only); (*e*) MINISTRY OF SUPPLY, 10. Age at least 27 on December 31, 1957. Candidates must have reached School Certificate credit standard in Mathematics or a science subject or have other approved qualifications (e.g. O.N.C.), but candidates otherwise well qualified by experience may be admitted. Every candidate must have had thorough experience in the duties of the class, and appropriate to the type of vacancy, gained by service in a Government Department or elsewhere.

Under (*a*) 10 posts are for electrical engineers, including communication engineers, 2 mechanical engineers, 1 marine engineer, 2 mathematicians, 2 chemists, 1 physicist, and 2 for general duties. The posts are at naval establishments in London, and the South of England.

The post under (*b*) requires knowledge of the processes of producing metallic silver.

Under (*c*) 1 post is at the National Physical Laboratory and calls for a good knowledge of thermometry; 2 posts are for electronic engineers at the Mechanical Engineering Research Laboratory, East Kilbride, near Glasgow; 1 post is at the Building Research Station, Garston, near Watford, Herts; 1 post is at the Pest Infestation Laboratory, Slough, Bucks, for work on problems of grain storage.

Under (*d*) 2 posts are at the David Bruce Laboratories, East Everleigh, near Marlborough, Wilts—1 for a bacteriologist and 1 in the Media Department; 3 posts at the Royal Army Medical College, Millbank, London, S.W.1—1 in the Serological Department, 1 in the Pathological Museum and 1 in the Virology Laboratory.

Under (*e*) the posts are classified: Glass blowing (1), Mathematics and Physics (4), Electronics (3), Engineering (1), Chemistry (1).

Fuller information about the duties and the kind of experience expected is given in the memorandum.

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Application forms and memorandum from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S4712/57/11. Applications to be returned by August 12, 1957.

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Application form and further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S128/57 and stating date of birth.

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e.g. Geology, Library, and Technical Information Services).

Age Limits: For Experimental Officers, at least 26 and under 31 on December 31, 1957; for Assistant Experimental Officers at least 18 and under 28 on December 31, 1957. Extension for regular service in H.M. Forces. Candidates aged 31 or over with specialised experience for Experimental Officer posts may be admitted.

Candidates must have at least one of a number of specialised qualifications. Examples are Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1957 may be admitted. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

Salary (London):

Experimental Officer, Minimum £925 (women £853); Men's scale maximum £1135.

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Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S94-95/57.

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MINISTRY OF LABOUR AND NATIONAL SERVICE. H.M. INSPECTORS OF FACTORIES (CLASS II). The Civil Service Commissioners invite applications from men and women for pensionable posts in the Factory Inspectorate, which is being expanded. Age at least 21 and normally under 30 on June 1st in the year of application. Extension of the upper age limit for regular service in H.M. Forces and for candidates with exceptional qualifications. Starting salary £545 (at age 21) up to £710 at 26 or over. Scale maximum £980. Somewhat lower outside London. A special increment of £25, within the scale, is granted after satisfactory probation. Higher posts filled by promotion from Class II.

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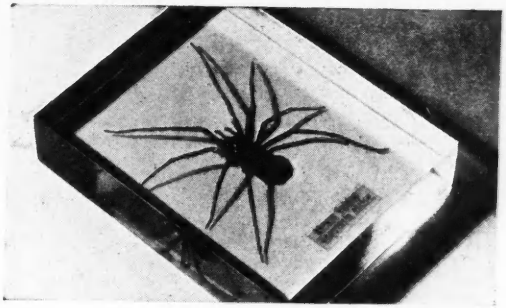

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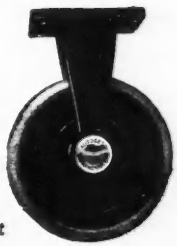

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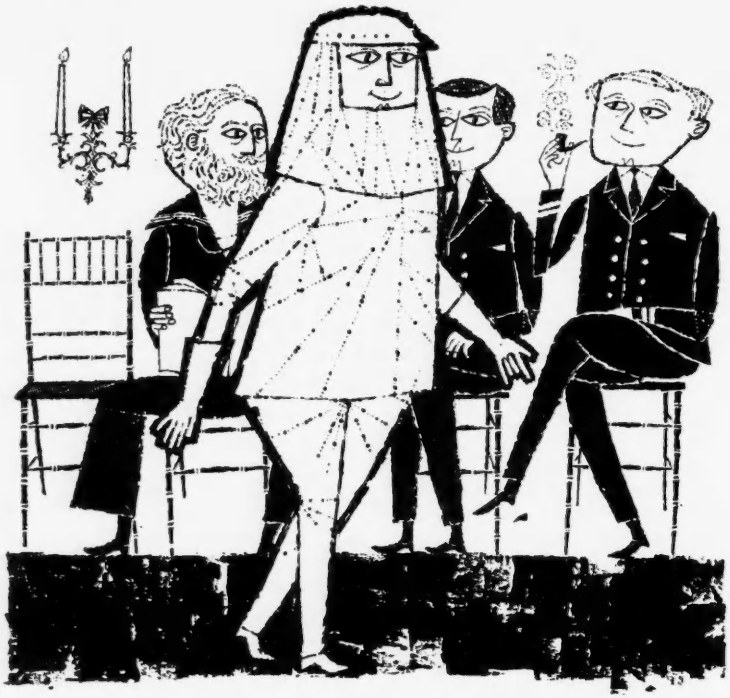

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